March 1959

space/aeronautics

Dec 3/9/59 MR J.

RESEARCH · DESIGN · DEVELOPMENT

aircraft / missiles / spacecraft

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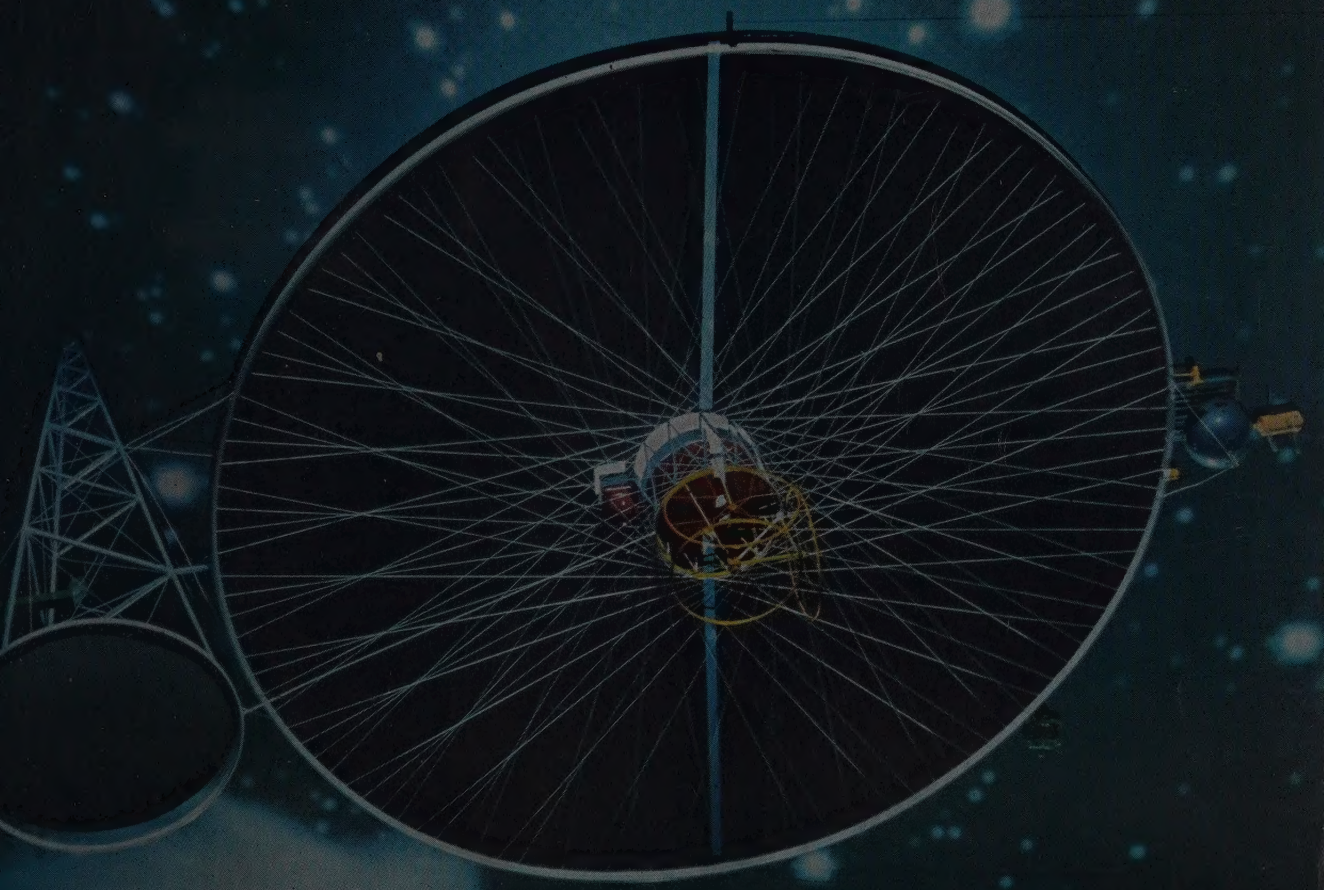

SPECIAL REPORT: **Space Flight**

A Conover-Mast Publication

New NASHVILLE Divisio

Structures for tomorrow's aircraft and missiles

To make ready for the future, Avco Manufacturing Corporation has created a new division at its Nashville plant devoted to design, development and production of aircraft and missile structures and assemblies.

Avco's new Nashville Division (formerly a part of the Crosley Division) boasts an enviable 17-year record of building components for some of the country's most important aircraft, including the B-52, B-47 and B-36.

Today it produces components for these aircraft:

Convair 880 jet airliner—horizontal and vertical stabilizer; wing tip, leading and trailing edges and flaps.

C-130 Hercules transport—complete empennage.

F-102 Delta Dagger—wing trailing edge.

F9F Cougar—horizontal stabilizer, flaperons and flaperettes.

Looking ahead, the Nashville Division has prepared itself to contribute to the Mach 3 aircraft and Mach 10 missiles that soon will go into production as part of the nation's defense effort.

The Nashville Division's skilled personnel have demonstrated their know-how in producing Avcomb, contoured stainless steel honeycomb panels. They long ago proved themselves in the production of aluminum honeycomb structures, and other advanced manufacturing techniques, such as metal bonding and chemical milling.

Avco/Nashville:
proven . . . ready for tomorrow

For further information, write: General Marketing Manager—Structures, Nashville Division, Avco Manufacturing Corporation, Nashville, Tennessee.

Avco / Nashville

NEW FORMAT . . . HOW DO YOU LIKE IT?*

This is the second issue of SPACE/AERONAUTICS in a new format. The outside dimensions have been cut to 8¼x11¼ inches—commonly referred to as "standard size"—and on the inside you'll find a more efficient package for the busy Technical Management reader.

Like many others that you've probably noticed during the past 18 months, these improvements are part of a continuing effort to provide you with the most useful technical information service possible———packaged for easier reading.

New typography, layout and styling were suggested by a professional magazine designer—based on the latest publishing techniques. But even more important, many of the improvements are the result of comments and suggestions by you, our readers.

For instance, over 2,500 of you recently took the time to fill out a 7-page questionnaire about your reading habits and use of SPACE/AERONAUTICS. And almost every one who did so also took the trouble to tell us how we could make the publication more useful and easier to read.

For example, we learned of the trend toward increased filing of technical articles. Better than 8 out of 10 of our readers are making use of SPACE/AERONAUTICS material for this purpose. Many of you commented on the difficulty of filing oversize pages or clipping articles that ran on in single columns for many pages. Many of you asked for some mechanical aid to help file articles for future reference.

Now there are two major sections of solid editorial—each section uninterrupted by advertising. In addition, there is a new feature, "Technical Article Abstracts," covering all articles in the issue. All you have to do is cut them out, mount on 3x5 cards and you'll have a permanent reference to all issues of SPACE/AERONAUTICS. To aid you further in your need to "clip and file," some features like "Design Progress" are printed on perforated pages —making them easy to remove and keep in a design notebook.

Most of you (about 9 out of 10) told us advertising was of definite interest. The majority use the ads to get answers to technical problems. So, even with solid editorial sections, we are making sure that advertising will not be bunched up in other parts of the magazine. You will also find a special reference in every issue which classifies all advertisements by product or service. This appears between the regular index to advertisers and the "Reader Service Card"—giving you a complete reference to all advertisements in any issue, as well as a direct channnel to the advertiser.

SPACE/AERONAUTICS offers you the industry's most complete and authoritative technical information service—in a greatly improved package to make it more useful.

Bill Maass

Publisher

***P.S. PLEASE DROP ME A NOTE . . .**

Our entire staff appreciates the guidance you have given us. We hope that after you've read this issue, you will take a few moments to jot down your comments on the back of this sheet. We'll be happy to hear from you.

YOUR COMMENTS:

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TITLE.....

COMPANY.....

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New York 17, N. Y.
Att. Bill Maass,
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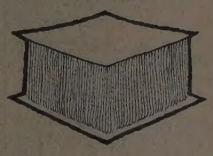
Where can **Rubberized Fabric** save for you?

Need strength, flexibility and portability in one lightweight material? Goodyear Rubberized Fabric may be your answer.

INFLATABLE, PORTABLE

Air Mat Fabric provides excellent insulation against heat, cold, vibration. Ideal for personnel shelters, portable scaffolding, shock cushioning. Beams made of this unique rubber-coated inflatable material have highest strength-to-weight ratio known.



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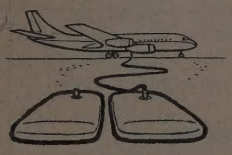
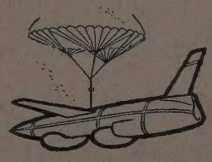
LOOK! COLLAPSIBLE FUEL TANKS

that unroll like a rug—can be set up, filled and pumping 45 minutes after delivery. Eliminates need for bulky, hard-to-handle metal drums. Designed for use wherever temporary or emergency storage of gasoline, oil, water—any bulk liquid—is required.



WANT TO BRING A MISSILE BACK?

Goodyear Recovery Bags—made of tough, rubberized fabric—fold into test missiles, inflate on way down to cushion ground impact. Saves the missile for firing another day, eliminates cost and weight of electronically operated conventional landing gear.



FOR DETAILED INFORMATION on rubberized fabric—and how it can save for you—write Goodyear, Aviation Products Division, Akron 16, Ohio, or Los Angeles 54, California.

AVIATION PRODUCTS BY

GOODYEAR

Inflatoplane—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio

MORE AIRCRAFT LAND ON GOODYEAR TIRES, WHEELS AND BRAKES THAN ON ANY OTHER KIND

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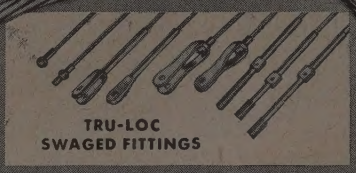
NEW "NO-MAG"

ACCO for Better Values

NON-MAGNETIC AIRCRAFT CABLES

- GOOD THERMAL CHARACTERISTICS
- CORROSION RESISTANT
- HIGH FATIGUE RESISTANCE
- HIGH ABRASION RESISTANCE
- PREFORMED CONSTRUCTION



TRU-LOC SWAGED FITTINGS

Eliminates Instrument Interference!

• Just as we expected, many aircraft designers were interested in the recent announcement of our new non-magnetic aircraft cable. If you did not see it, "NO-MAG" has these characteristics:

NON-MAGNETIC PROPERTIES . . . "NO-MAG" cable is made from type 305 stainless steel. It remains non-magnetic after severe cold working —in contrast to standard stainless steel aircraft cable which shows a pronounced increase in magnetism after swaging, wire drawing or similar operations.

This non-magnetic property of "NO-MAG" cable eliminates instrument interference from cable magnetism.

CORROSION RESISTANCE . . . New "NO-MAG" cables have corrosion-resistant qualities similar to, but slightly better than, cables made of standard stainless steel.

GOOD THERMAL CHARACTERISTICS... The thermal expansion characteristics of new "NO-MAG" cable are much closer than those of standard stainless steel or carbon steel cables to the characteristics of aluminum alloys used in aircraft. This greatly simplifies maintaining cable tension under various changes in temperature.

HIGH FATIGUE RESISTANCE . . . Preformed construction and careful processing give new "NO-MAG" cable high fatigue resistance.

HIGH ABRASION RESISTANCE . . . New "NO-MAG" cable shows greater abrasion resistance than standard stainless steel aircraft cables.

TENSILE STRENGTH, while lower than that of stainless and carbon steel, is sufficient to enable replacing these, size for size, with "NO-MAG" on many applications where the characteristics of "NO-MAG" are required.

USE WITH SWAGED TERMINALS . . . Swaged terminals can be applied to standard AN dimensions.

COMPLETE RANGE OF SIZES, CONSTRUCTIONS . . . New "NO-MAG" is furnished in sizes from 1/16" to 1" in all of the standard aircraft cable constructions.

Get the complete story on this new technical development for the aircraft industry. Write today to Detroit office.

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space/aeronautics

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CECO NEWS

HANDLER-EVANS SYSTEMS • CONTROLS WEST HARTFORD, CONNECTICUT

Chandler-Evans Announces New High-Temperature Test Center

CECO Facility Tests Fuel Devices In Environments To 1000°F.

West Hartford, Conn. (CECO)—Completion of a new and vastly capable Thermo-Research Center has been announced by Sidney A. Stewart, General Manager of Chandler-Evans. The 100% company-owned facility is considered to be unique in the modern aircraft industry. It is designed to subject sensitive fuel mechanisms and other hydraulic devices to elevated temperatures similar to those developed in ultra high-speed flight.

As a development tool, the Center is expected to provide answers to many questions that have perplexed engineers since advanced air speeds first began to create critical high-temperature problems.

Chandler-Evans has been "hot-testing" aircraft engine accessory products for a number of years. Initially, relatively simple facilities were equal to the task. But, as aircraft and missile speeds advanced into Mach ranges, it became apparent that temperature [illegible] (to accommodate 300-hour fuel system tests, for example) can be carried out twenty-four hours a day, seven days a week.

LATEST CECO DEVELOPMENT TOOL: Two structures make up the Chandler-Evans Thermo-Research Center. One (shown above in foreground) is a concrete and steel, insulated and soundproofed Control House.

The second structure (background above) is an "open air" Test Platform, sheltered from the elements by a sheet metal roof containing plastic blow-out sections. Test Chambers and all associated equipment are installed on this platform.

Others to Use Lab

CECO's new Thermo-Research Center has been made available to others, according to Ercole J. Vitali, Manager of the Company's Engineering Test and Experimental Departments.

On a limited basis, the laboratory and its staff will be put at the disposal of manufacturers who are similarly concerned with the functional performance of liquid fuels, fuel system components, and other hydraulic equipment when subjected to the stresses of elevated temperature. Ambient and fuel temperature capabilities currently specified are 1000°F. and 500°F. respectively.

Vitali went on to say that subcontract customers can gain valuable time and save money as well by calling on CECO's

New Center Has Unique Features

The Control Console in CECO's newest test facility incorporates latest state-of-the-art instrumentation and provides for push-button ease of operation. Any malfunction in any part of the system activates both audible and visual alarms. Electrical interlocks automatically shut down the system and indicate the specific area of malfunction.

If the operator does not or cannot take the necessary corrective steps within a predetermined amount of time, required corrections are made automatically and the test is resumed.

Engineered for Safety

While the Test Platform with its Ambient Chambers can easily be seen through a maximum safety window in the forward wall of the Control House, all tests are 100% remotely controlled. Operators set and control temperatures and pressures, and assemble all necessary data at the Control and Instrumentation Console.

The entire CECO Thermo-Research Center has been painstakingly engineered to provide optimum safety, both for operating personnel and for the valuable mechanisms being tested.

So thorough are the safety precautions that despite the hazards inherent in handling fuels at elevated temperature, lowest premium cost fire insurance premiums on this facility are in the category ("Sprinkler Rating").

Described as "Operator-Proof"

A highly complex operator-overriding system, developed especially for this facility, assures proper operation at all times. Operator errors, if and when they occur, are corrected automatically.

Fuel Density Indicator

A meter in the Control House gives continuous indication of fuel density. It gets its signal from the intensity of radiation through a section of the fuel conduit. Isotope Cesium 137 is used in this radiation process.

S. A. Stewart Lauds CECO's New Test Lab

"This unique engineering tool will enable CECO to continue developing superior products empirically," said Sidney A. Stewart, General Manager of Chandler-Evans, when the company's new Thermo-Research Center was unveiled for the aircraft industry.

He went on to point out that high-temperature problems have become increasingly critical with advancing speeds of air and space vehicles. "We expect to find in this new laboratory definitive answers to a variety of questions relative to the precise metering of liquid fuels at high temperatures," he said.

Further underscoring the importance of *temperature extremes* in the modern aircraft and missile industry, Stewart mentioned concurrent activities in the cryogenics field. He said CECO is designing and producing devices for use in liquid nitrogen systems, for example, where temperatures of —330° F. are encountered.

Part Numbering

To simplify trouble-shooting and minimize time losses when repairs or replacements are re-

Magnet Calibration

TRANSISTORIZED
DIRECT READING

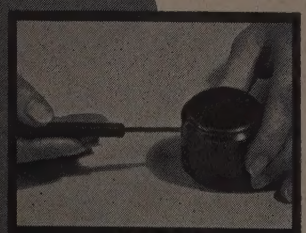
Gaussmeter

provides nine full-scale ranges

MODEL 1295A

RANGES (Gauss)		
0-100	0-1000	0-10,000
0-200	0-2000	0-20,000
0-500	0-5000	0-20,000 plus

This stable, all transistorized Gaussmeter operates on the Hall Principle and provides a conservative accuracy of ±3% over-all ranges. Accuracy can be increased to ±1% at any point between 500 and 20,000 gausses by use of special probe reference magnets. Response is flat when measuring magnetic fields from DC up to 120 cps. Correction curves are supplied for measurement of fields up to 400 cps.



TYPICAL REFERENCE MAGNET

Unit is supplied with a 1000-gauss ±¾% probe reference magnet and one standard probe. Nominal probe thickness is 0.025". An ultra-thin probe, measuring 0.007" is available on special order. Sensitive element area of probes is approximately 0.017 square inches.

Probe Reference Magnets

The Model 1295A Gaussmeter operates from 115-volt, 50-400 cycle power line. Internal switching arrangement and battery holders are also provided for self-contained battery operation. Compartment in back of aluminum case provides storage for probe, reference magnet and power cord. Over-all size is 11 x 7 x 12. Weighs 12 lbs. Net price $420. complete.

Prices are f.o.b. Boonton, N.J. & subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

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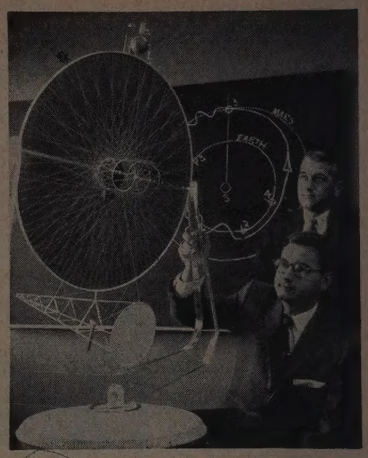
cover story



Mars probe for a three-year exploration trip from an earth orbit and back was proposed by Henry K. Hebeler and Richard D. White, of Boeing's Systems Management Office. Propelled by an ion engine, the unmanned craft would measure about 40 ft across and weigh 600 lb.

The probe would examine the surface of Mars from a height of 8000-9000 miles through a large telescope. The telescope in turn would be scanned by a TV camera whose image would be optically transmitted to the earth at white-light frequency.

All moving parts on the probe would be driven electrically with power from an array of solar batteries. Basic materials would be beryllium, steel (for tension wires), honeycomb-core sandwich (for reteries. Basic materials would be flectors), and quartz (for navigation system lenses). A preprogramed memory and a star tracker would take care of coarse and fine trajectory control, respectively.

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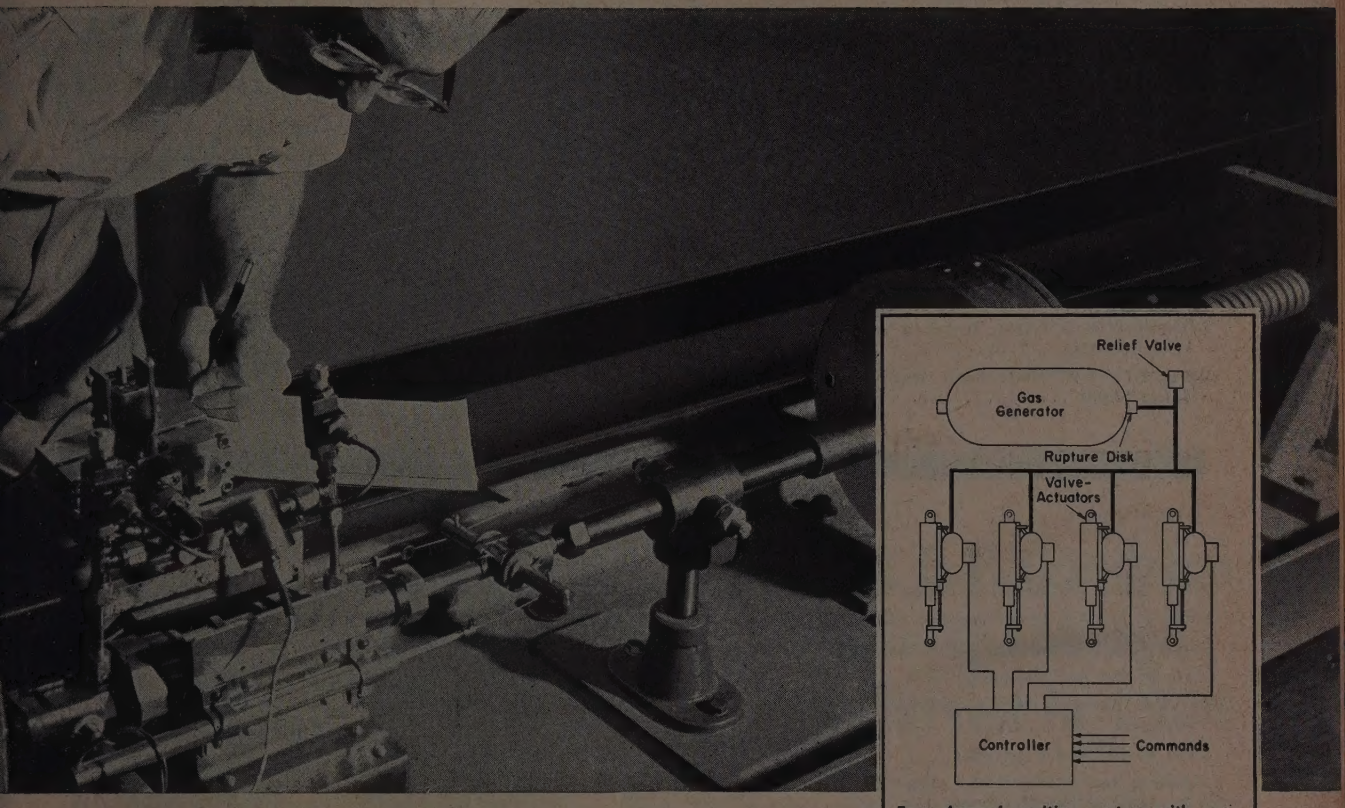
WHERE HYDRAULICS WON'T PERFORM . . .

GAS SERVO SYSTEM



Four-channel position system with common hot-gas generator, designed for thrust-vector control.

Ideal For High Temperature and Radiation Environments, G-E Gas Servos Are Compact — Give Fast Positioning Response

General Electric has developed a new gas servo device for actuation control systems where hydraulic servomechanisms are undesirable. Basically a force servo with position and velocity feedback, it consists of only three major components—an energy source, a valve-actuator unit, and a feedback and stabilization network.

By using the energy directly, rather than converting it to hydraulic power first, the system can tolerate ambient temperatures of 750F and higher. And, by eliminating this energy-conversion step, the number of components is kept at a minimum, simplifying the design, and thus increasing reliability.

As a hot gas servo, a solid propellant is stored in a gas-generating unit that also acts as an accumulator. When ignited, the gases fill the accumulator before entering the pressure-controlled, two-stage servo valve. The bleed-type first stage regulates the pressure in the second stage. This diverts the gas to either side of the actuator to control output force.

As a cold gas servo, with air or an inert gas as the energy source, the same system reduces contamination problems in high nuclear-radiation areas. In addition, the "closed-center" type valve also offers operating economies in such a system, when using stored gas or a closed cycle in which the gas is reused.

This servo system design offers several advantages over other approaches:

1. High frequency response is possible through pressure-type control. For example: 20 cps at 90-degree phase lag, with a 250-pound load. Higher response is possible with increased control bleed flow.
2. The unit is flexible. Damping, stiffness, and accuracy characteristics are controlled electrically. No change in hardware is needed.
3. Poppet valves minimize leakage. They have no close-fitting sliding parts and are well suited for high-temperature operation.
4. Symmetry of design lessens thermal shock problems, minimizes effects of G-forces, and avoids null shifting.

A dry system, the G-E servo eliminates virtually all the problems resulting from the static storage of liquids—thermal expansion, leakage, evaporation, etc. This reduces maintenance and insures instantaneous readiness.

If you'd like more information about G.E.'s gas servo and how it could help simplify your positioning-control designs, just fill out and mail the attached coupon, or contact your nearest General Electric Aviation and Defense Industries Sales Office.

Manufactured by General Electric's Aircraft Accessory Turbine Department, West Lynn, Massachusetts

Progress Is Our Most Important Product

GENERAL ELECTRIC

Section C231-22, General Electric Co.
Schenectady 5, New York

Please send me "Gas Servo System" bulletin, GEA-6846.

☐ Immediate Project ☐ Reference Only

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March 1959

volume 31, number 3

space/aeronautics

RESEARCH · DESIGN · DEVELOPMENT

aircraft / missiles / spacecraft

Technical Management

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The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.

1934 Stratosphere Suit

1958 Lightweight Full Pressure Suit

B.F.Goodrich

At B.F. Goodrich the space age started in 1934

That was the year B. F. Goodrich developed the first rubber stratosphere flying suit for attempts at setting altitude records. Through the years this suit has been constantly improved to meet the needs of higher-flying pilots. And when the first man sets foot on the moon he will probably be wearing a modification of today's B.F.Goodrich Full Pressure Suit.

B. F. Goodrich engineers are working in many ways to help man break the bonds of earth—and return safely. Missile nose cones, improved solid fuels, propellant heaters, missile battery box heaters, instrument heaters, printed and etched circuits, stronger metal and plastic structural materials, insulating materials, precision rubber seals and gaskets, blind fasteners—these are only a few of the items that may help solve *your* space age problems. For specific R & D information, write: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. SA-39, Akron, Ohio.*

B.F.Goodrich *aviation products*

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up a permanent record for future reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space Flight
(Special Report)

Astia code: 2-1; 9-5; 14-1, -2; 17-2, -4, -6; 25-8
Your code:

State of the art: Structures and materials

Review of trends in overall and detail structural design and materials use for spacecraft, with special emphasis on weight factors, re-entry problems, and sealing techniques. Structural cooling methods are diagramed.

space/aeronautics 31/3 (March '59) p. 40

Space Flight
(Special Report)

Astia code: 2-1; 10-5, -6; 27-3
Your code:

State of the art: Propulsion

Review of trends in overall design, accessories, and materials for spacecraft propulsion systems and of propellant developments. Trend toward simpler components is stressed and requirements of new propellants are listed. Outlook for electric and nuclear propulsion is discussed.

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Space Flight
(Special Report)

Astia code: 2-1; 14-2, -4; 25-8
Your code:

Conduction cuts heating during spacecraft re-entry

Evaluation of possible cooling methods for leading edge regions of re-entry vehicles. Conduction is shown to be very promising for reduction of temperatures and thermal gradients. Simplified equations for calculating leading edge temperature history are presented.

by Carr B. Neel, NASA

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Space Flight
(Special Report)

Astia code: 2-1; 10-5, -6; 27-3
Your code:

High Specific impulse vs lightweight hardware

Relationships between specific impulse, propulsion hardware weight, staging, and burnout speed for orbital and escape missions. A suitable form of the burnout speed equation is given and typical curves are shown.

by William J. Reinhardt, Reaction Motors

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Space Flight
(Special Report)

Astia code: 2-1; 9-1, -3, -5, -6; 25-8
Your code:

State of the art: Dynamics

Review of dynamic factors in spacecraft design, from aerodynamics to orbit mechanics, with particular emphasis on test facility problems (shock tubes, helium tunnels, etc.). Interrelationship of heating effects and dynamic design and trajectory problems are discussed.

space/aeronautics 31/3 (March '59) p. 46

Space Flight
(Special Report)

Astia code: 2-1; 8-3; 27
Your code:

Plasma accelerator for spacecraft control (Design Progress)

Design analysis of an electromagnetically propelled plasma engine for spacecraft control. Electric circuit and method of pulsing the lab-model plasma gun are detailed. Gas-velocity measurement technique is described. Table of typical performance data, including thrust, for various energy inputs is presented.

by Bernard Kovit, Associate Editor

space/aeronautics 31/3 (March '59) p. 57

Space Flight
(Special Report)

Astia code: 2-1; 9-1; 19-1
Your code:

Accurate position data needed for space course changes

Position data needs for making corrections of interplanetary space vehicle trajectories. Methods of determining a vehicle's position in the solar system and the effect of course changes on fuel consumption are discussed. The most useful forms of motion equations for these calculations are given.

by E. V. Stearns & W. E. Frye, Lockheed Aircraft

space/aeronautics 31/3 (March '59) p. 48

Space Flight
(Special Report)

Astia code: 2-1; 7-5; 8-1, -2, -3, -4, -5, -6, -7; 25-7
Your code:

State of the art: Electronics

Factors that will make space electronics different from designs in aircraft and missiles are listed. Molecular "circuits" are discussed, electric power possibilities for space vehicles are examined, and the role of electronics in space communications and navigation is sketched.

space/aeronautics 31/3 (March '59) p. 61

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Forces Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space Flight (Special Report) — Astia code: 2-1; 8-3; 9-2 Your code:

Shock ionization changes EM propagation characteristics

Analyzes how EM wave propagation, antenna impedances, radar cross-sections, voltage breakdown properties, and receiver noise levels are affected by the ionized sheath surrounding hypersonic vehicles moving into or out of a planetary atmosphere. Gives formulas for determining dielectric constant and conductivity of the ionized gases.

by W. B. Sisco & J. M. Fiskin, Douglas Aircraft
space/aeronautics 31/3 (March '59) p. 65

Space Flight (Special Report) — Astia code: 2-1; 28-1, -3 Your code:

What instruments for space crews?

Suggested approach to development of instrumentation for manned spacecraft. Three-dimensional automatic star tracker and computer is proposed with which position in space can be displayed in two dimensions. Sensors and display of data for radiation levels, meteorite damage, and re-entry thermal gradients are also considered.

by George W. Hoover, Benson-Lehner
space/aeronautics 31/3 (March '59) p. 110

Space Flight (Special Report) — Astia code: 2-1; 7-5; 20-7 Your code:

State of the art: Accessories

Review of requirements, performance characteristics, and limitations of accessory components and systems for spacecraft. Typical units for X-15, Dyna-Soar-type vehicles, instrumented satellites, and manned space capsules are cited. Photos of GE one-man capsule mockup, showing details of accessory installations.

space/aeronautics 31/3 (March '59) p. 72

Space Flight (Special Report) — Astia code: 2-1; 28 Your code:

Biosatellite decompression (nomographs)

Two nomographs for quick and easy comparison of decompression conditions in inhabited satellites: (1) determination of time of decompression from 14.7 psi to any cabin equivalent altitude up to 50,000 ft from cabin volume and puncture area; (2) determination of decompression flow rate from cabin pressure and puncture area.

by Eugene B. Konecci, Douglas Aircraft
space/aeronautics 31/3 (March '59) p. 117

Space Flight (Special Report) — Astia code: 2-1; 7-5; 20-7 Your code:

Evaluating APU systems for spacecraft

Comparative analysis of electrochemical, solar, nuclear, mechanical, and gas expansion systems for providing auxiliary power for spacecraft. Curves of system weight vs duration are plotted for several horsepower levels, and areas of optimum weight use are shown for each system.

by S. L. Sandelman & R. W. McJones, Aero Hydraulics Div., Vickers
space/aeronautics 31/3 (March '59) p. 86

Space Flight (Special Report) — Astia code: 2-1; 27-3 Your code:

Optimized boost system staging (nomograph)

Nomograph for finding optimum mass ratios and optimum payload-to-gross-weight ratios of multi-stage rocket vehicles from specific impulse, burnout speed, net payload, and takeoff-burnout weight ratio. It can be used to determine the best staging for given space missions.

by R. C. Kollyer & C. E. Vandenberg, North American Aviation
space/aeronautics 31/3 (March '59) p. 118

Space Flight (Special Report) — Astia code: 2-1; 28-1, -3, -5 Your code:

State of the art: Human factors

Review of current levels of development and study on human factors of manned space flight. Acceleration and radiation studies are detailed, and design parameters are analyzed for shielding, sealed cabin, closed ecologies. Psychophysical problems are outlined.

space/aeronautics 31/3 (March '59) p. 98

Space Flight (Special Report) — Astia code: 2-1; 5-2; 8-1, -3 Your code:

Space communications

(1) graph of space loss and time lag vs distance; (2) graph of antenna height and Doppler shift vs distance or velocity; (3) graph of absorption plus attenuation, free space loss plus antenna gain, line loss, and noise figure vs frequency; (4) graph and table of transmitter power vs distance for system design.

by F. W. Lehan & Leang P. Yeah, Space Electronics Lab & Westinghouse Electric, resp.
space/aeronautics 31/3 (March '59) p. 120

continued on page 13

(Advertisement)

Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

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in this issue continued from page 11

Space Flight
(Special Report)

Astia code: 2-1
Your code:

Orbit relationships (nomograph)

Nomograph for finding satellite velocity, altitude and flight path angle, orbit period and eccentricity, and time since perigee and angular location vector displacement from perigee for original and artificially changed orbits from burnout altitude, velocity, and flight path angle, and retro-thrust.

by H. H. Luetjen & M. O. Ramey, McDonnell Aircraft
space/aeronautics 31/3 (March '59) p. 122

Space/Aero Electronics

Astia code: 1-1; 8-2, -3; 12-2
Your code:

Adaptive controls for future automatic flight (Design Digest)

Survey of new trend in aircraft, missile, and spacecraft control system design to adaptive controls. Five leading design philosophies are shown schematically and described. Use of variational calculus for optimizing control design is discussed.

by James Holahan, Electronics Editor
space/aeronautics 31/3 (March '59) p. 152

Space/Aero Electronics

Astia code: 8-1, -2, -3, -4, -5, -6
Your code:

Log periodic antennas break bandwidth barriers

Electric characteristics of new log periodic broadband antenna. Structures for use with systems below one kmc in frequency are described in detail. However, the principles discussed apply across the entire use spectrum from HF through microwave.

by R. H. DuHamel, Collins Radio
space/aeronautics 31/3 (March '59) p. 148

Space/Aero Electronics

Astia code: 3-1; 6-6; 8-3, -5
Your code:

Missile detection by satellite

First article in a two-part series on problems in designing a satellite recon system for detecting the firing of ICBMs. Optical detector is analyzed through comparison of S/N components of the output current resulting from background illumination.

by Du Mont Labs
space/aeronautics 31/3 (March '59) p. 157

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Want to get more information on products or services advertised or mentioned editorially in this issue? Then use our handy Reader-Service Card opposite **page 186**. It's simple—just write in the number of the item you're interested in, drop the card into a mailbox, and we'll forward your inquiry.

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coming next month

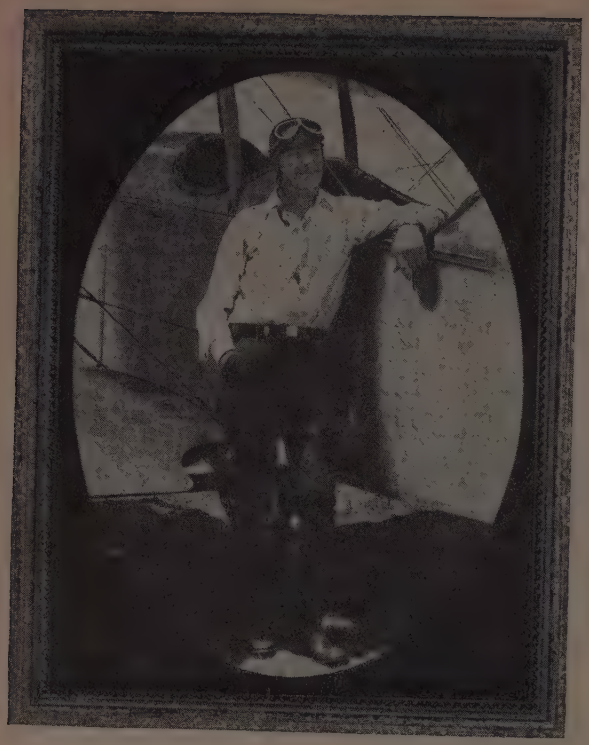
ARE SUPERSONIC airliners a pipedream or the logical successors of today's 707s, DC-8s, and Comets? The industry itself, most recent comments indicate, isn't quite sure about the right answer to this one. Next month, SPACE/AERONAUTICS will attempt to give the answer on the basis of a down-to-earth engineering analysis.

SOLAR CELLS, clearly destined for a major role as spacecrafts APUs, will be covered in a detailed review of design and operating features.

THE FINAL article in the revealing series on Russian nuclear engine work will deal with the various types of airborne reactors foreseen by Soviet designers.

coming soon

TWO UPCOMING articles will deal with the intriguing problems of keeping man alive in space. One will spell out the environmental requirements for a space cabin of relatively short duration; the other will go into the feasibility of algae regeneration systems.



There's a new kind of airplane ahead for America's new generation of pilots

Gramp raced through the skies at nearly 100 miles an hour. He flew his fabric-covered biplane by the seat of his pants and the wind in his face.

Some twenty years later, his son flew a P-51 Mustang at better than 400 mph... later on flew a Sabre Jet that approached the speed of sound. There were more dials to watch, more controls to work, till he wondered if airplane designers hadn't reached the limit of human capacity.

Today's Air Force pilots can look forward to piloting a new kind of airplane. It will fly more than 2,000 miles an hour... carry an electronic crew to navigate, find targets, fire weapons, evade attack. Most significantly, its pilot will have as much time as Gramp did to do what man does best: make decisions.

For though machines can see farther, figure faster, and react quicker than men, they cannot cope with the unexpected—nor can they be recalled or redirected. That is why America needs the judgment of men as well as the automatic deadliness of missiles. Her deterrent power will always depend on building the most advanced manned and unmanned weapon systems—and keeping them ready for action.

Three times the speed of sound

North American is now at work on two Mach 3 airplanes for tomorrow's Air Force—the B-70 bomber for the Strategic Air Command and the F-108 interceptor for the Air Defense Command.

The B-70 will skirt the edge of Space to any target on earth—*flying every mile of the way at more than 2000 mph.* It will carry the most advanced weapons, including missiles it can launch hundreds of miles from ground defenses or primary targets—plus countermeasures against enemy attack.

The F-108 will be able to detect and identify incoming airborne weapons—manned or unmanned—over 1000 miles from our shores... and destroy them.

These manned weapon systems will give true depth and flexibility to our nation's deterrent power.

Mobilizing America's best for the job

North American, as weapon system manager for the B-70 and F-108, has been charged with complete scientific, engineering, and administrative responsibility. To enlist the best brains and specialized skills of American industry, North American has divided each airplane into major subsystems, which are being awarded to the contractors best qualified to handle them.

Though these projects are among the most important ever entrusted to one company, North American's knack for turning revolutionary concepts into revolutionary airplanes is a matter of record. Time and again, North American's designers and engineers have exceeded expected performance—yet made the new airplane practical to build, fly, maintain. This sure hand—result of building more aircraft than any other company in the world—has created more air power for fewer tax dollars.

THESE FAMOUS AIRPLANES WERE READY WHEN AMERICA NEEDED THEM

Subsonic P-51 Mustang—did valiant service in World War II.

Transonic F-86 Sabre Jet—drove the MIGs from the skies of Korea.

Supersonic F-100 Super Sabre—mainstay of the Free World's fighter strength.

Hypersonic X-15—soon to carry the first American to the fringes of space.

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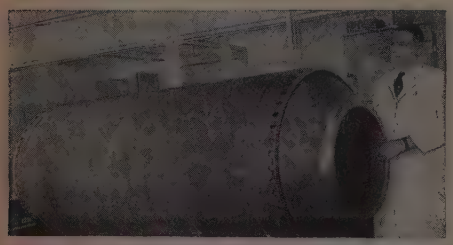

QUALIFIED ENGINEERS: Investigate interesting opportunities at Ingersoll Kalamazoo Division.

The Ingersoll Kalamazoo Division has been producing missile metal parts since 1951 when the first Snark booster cases were made. Today, nearly half the Nike Hercules boosters and sustainers have been made with Ingersoll Kalamazoo Division production skills.

RESEARCH AND DEVELOPMENT and prototype fabrication are going on at the Ingersoll Kalamazoo Division utilizing such new methods as hydrospinning and concussion, or explosive, forming, which provide today's solutions to problems in metal parts production.

FABRICATION AND ASSEMBLY on a PRODUCTION line basis of large missile parts is routine at the Ingersoll Kalamazoo Division involving such processes as annealing, machining, hydrospinning, welding, rolling, etc.

A capable staff of engineers is available at the Ingersoll Kalamazoo Division who are experienced in the DESIGN, FABRICATION AND ASSEMBLY of major missile hardware parts. These engineers are ready to tackle your problems.

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editorial

Playing Russian Roulette?

UNEASINESS is something Americans concerned about defense are filled with these days.

In the first place, the Reds are getting dangerously confident. They joyfully shoot down our unarmed transports and lie outrageously about it. They tell us to clear out of Berlin, or else . . . We snort like a bull and say, No retreat.

One would think that if we mean what we say, we'd start getting ready for the worst. Such as beefing up the Army, since the first test will be to keep open our supply routes to the city.

Nothing of the kind is happening. Instead, the Army's manpower and weapons are cut further. Chief of staff, Gen. Maxwell Taylor, says he needs more funds for weapons modernization, manpower, and anti-missile missiles. So his budget gets chopped from $12.5 to $9.9 billion.

Navy funds for missiles, aircraft, anti-sub warfare and Polaris submarines are reduced. Admiral Burke's "hard" budget of $14 billion came out of the Administration's meat grinder at $11.5 billion. The Air Force's pressing need for more supersonic B-58s and other weapons to meet its mission requirements was answered by the ringing ax to the tune of a $3 billion dollar cut.

ON TOP of this, Defense Secretary McElroy says we won't try to match the Reds in missiles. We have, therefore, resigned from the missiles "race."

Are we tired of living, or do we just like living dangerously? In the Berlin "crisis" we are looking into a gun barrel. The Administration feels that the trigger won't be pulled, or if it is, the hammer will click on an empty chamber. At least the budget reads that way.

The President and his advisers may be right. But the game of Russian roulette isn't usually played by normal people. You have to be slightly nuts.

It is assumed the Russians will not really risk a major war. It also is assumed they won't exploit their admitted lead in ICBMs and IRBMs.

So, by happy Administration faith—that the Reds will not fully use their potential missile capabilities—we, who have proudly led the world, have chosen not to lead anymore. Or even to catch up. This already has shocked our allies. And it may well lead to bolder Soviet ventures.

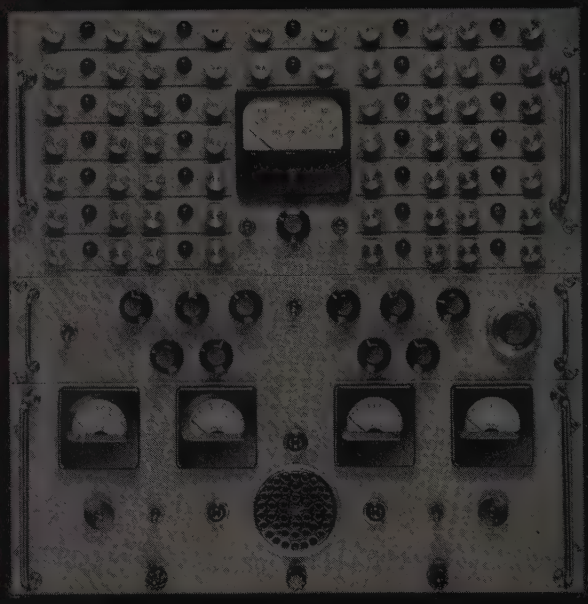
Yet, while defense is skimped, non-defense spending jumps skyward—by some $9.2 billion since 1953, while defense is $4.3 billion below 1953. Without adding one penny to the total budget, we can stop skimping on defense. Transfer most of the $7 billion for agricultural subsidies. Take more billions from the rivers and harbors porkbarrel. From housing subsidies. From veterans spending.

It can be done. Are we unwilling to try? . . . ***Randolph Hawthorne***

New....ARNOUX miniature

DECOMMUTATOR

FOR PAM and PDM TELEMETRY SYSTEMS



The new Arnoux Model TDS30-1 Decommutation System is completely self-contained within three chassis assemblies consisting of: Gating Unit (TOP), Pulse Selector (MIDDLE) and Regulated Power Supply (BOTTOM). The unit handles 28 channels of information and occupies only 19½ inches of panel height in a standard relay rack. Overall depth behind panel is 13 inches.

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The Arnoux Model TDS30-1 Decommutation System is compactly designed for use in airborne or trailer installed telemeter receiving stations and in portable check-out equipment.

- Miniaturization is the natural result of a new circuit design allowing the entire system to contain only 76 tubes as opposed to several hundred in competitive systems.
- Modular construction permits easy expansion of system to any desired channel capacity.
- Novel circuitry design does not reflect errors due to center frequency drift of sub-carrier oscillators, drift of discriminator D. C. output level, or tape playback speed errors.
- Built-in test selector permits visual inspection of waveforms throughout system for quick malfunction detection.
- Neon indicators on each gating unit give continuous visual indication of correct sequential operation.
- System accepts all standard IRIG inputs, either PAM or PDM, at any sampling rate from 75 to 900 per second.
- Overall linearity is within ± ½ % at maximum level. Long term level drift is within ± ½ %. Gain drift is negligible.
- Modular plug-in gating units allow quick replacement of faulty channels.
- Two spare units are maintained on standby for instant use.
- Power required is 115 volts, 60 cps, single phase. Optional 115 volt, 400 cps, power supply available for airborne application.

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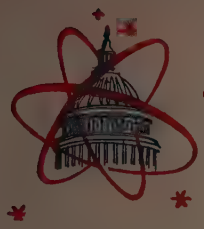


washington briefing

by A. N. Wecksler, Washington Bureau Chief

Trend to weapon systems will continue

SHORT production runs have become the order of the day in making our major missiles. The same trend will apply to the Mach 3 family of aircraft.

Reason simply is that the most advanced weapons are too effective, too expensive, and too complicated.

In contrast, it can be assumed that 150 copies of the Atlas will be bought—possibly more, maybe less, depending on our success with the Titan. Production runs on the second-generation Minuteman are not likely to reach high numbers.

There is no indication of how many Mach 3 F-108s and B-70s might be bought. However, the early cost figures on these aircraft are so large that long production runs of these models would preempt a good part of the total military budget.

In all cases, cost is the ultimate limitation on numbers, and at each stage of development costs have increased. New weapon systems will operate under exotic conditions, at extremely high speeds and temperatures—all of which means complexity and close manufacturing tolerances.

Effects on Government and industry will be marked. Short production runs mean less mass production. Complexity means involved technology.

This calls for a higher degree of technical training on the part of the administrative staffs at Washington and Dayton, Ohio, acting for the Air Force, and a similar trend in Army Ordnance, BuAer, and BuOrd.

Also it means that the trend of weapon system development, with the contractors taking major responsibility for specific systems, will continue. This approach has been highly criticized by members of Congress who claim that the services have relinquished control—also that the weapon system contracting approach tends to shut out competitive bidding by small manufacturers.

Be that as it may, the weapon system approach was born of necessity—because of the complexity of the product, and because of some whim of military buying.

Negotiated contracts are another outgrowth of the need for complex units, with no room for error. Here again necessity will dictate incentive-type contracts, as against fixed prices, in most cases.

Effects on industry will be equally forceful. Dollar volumes of contract will be as much, or more—fewer units, with each unit selling at a much higher cost.

Complexity also will hit the plant floor, calling for distinct changes in types of plant, personnel and plant practices. In physical plant requirements, some missile work completely rules out the use of the existing aircraft assembly plants.

Gen. Orval Cook, retired USAF Deputy Chief of Staff for Materiel and president of AIA, described a recently built, typical facility for making a complex missile component as calling for:

- Assembly in a vibration-free area, which required special foundations to still vibration from adjacent factory and street traffic.
- Assembly room that must be surgically clean, which requires several types of equipment to prevent dust particles from entering the area.
- **Parts that must be assembled under rigid temperature and humidity control, and such control measures had to be built into the plant.**
- Outside the final assembly room, elaborate test equipment had to be installed, which needed special foundations, as did complex computer-operated manufacturing tools.

On the manpower side, the number of persons employed in the industry will remain about the same — roughly 750,000. But the nature of employment and the character of employes has changed, and will continue to change.

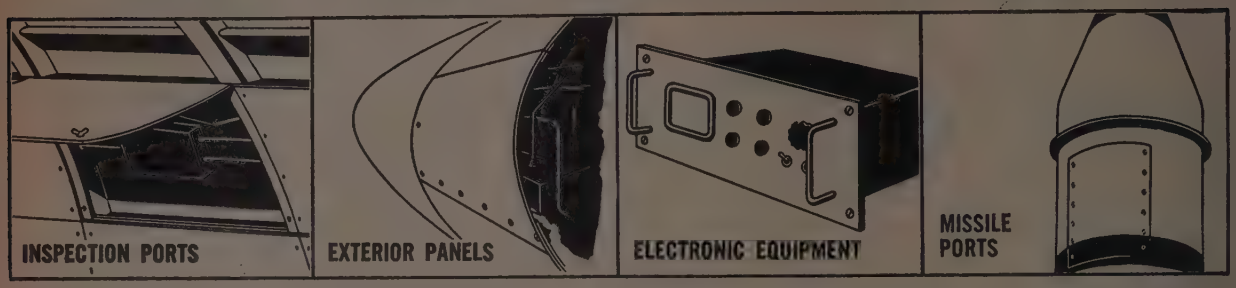
Engineers are increasingly in evidence on the plant floor. The production worker is being displaced by higher skills, and the ratio of engineers to production workers will increase.

While the new technology will not use mass production methods, the process of inspection and testing will use the most advanced computer controls.

Net effect is that the modern weaponry will be manufactured and assembled under lab conditions, by engineering and highly skilled production talent, working under tight specifications set by scientists.

FLIGHT-PROVED RELIABILITY . . .

LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS

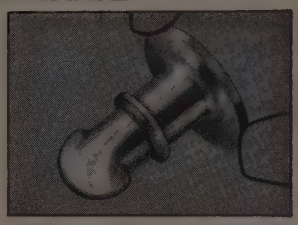


Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.



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For use where space is limited and where weight must be kept at a minimum.

LION NO. 5 FASTENER
For heavy-duty applications where good tensile and shear strength are required.

FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.

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LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.

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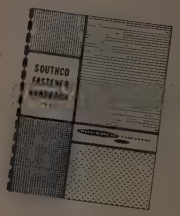

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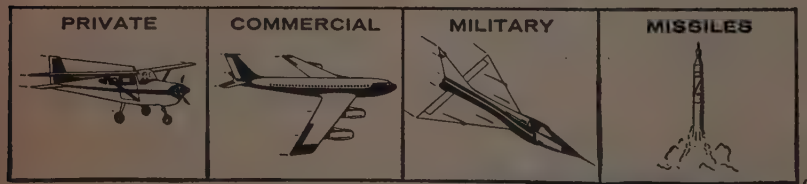

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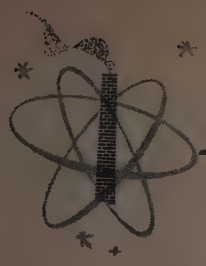

industry viewpoint

by **Robert M. Loebelson,** Associate Editor

Gross national product vs space flight

ARE WE getting off base in quickening our astronautics pace? One man who believes we are is Dr. W. T. von der Nuell, chairman of the research board at The Garrett Corp. Basically responsible for the Los Angeles company's long range planning operations, Dr. von der Nuell thinks this country is wasting its top brains in science and engineering.

"Sure the Russians have high-caliber technical talent," says the German-born propulsion expert, answering an obvious objection. "But there is no point in getting overly excited about that fact."

Pointing to his own experiences in Germany during World War II as head of a turbo machinery research organization, he claims the Germans probably lost the war because of U. S. productivity. "We are now ignoring the fact," he declares, "that the total possible impact of space on the number of productive manhours in the U. S. is negligible."

Dr. von der Nuell does not advocate that the U. S. abandon or even downgrade its space program. But he thinks that this country should follow the principle of first things first. "We have to participate in the space race for defense and diplomatic reasons," he concedes. "But we must also recognize that space activities are not going to fill the national breadbasket."

Our most vital concern, says Dr. von der Nuell, is to keep the national economy and productivity curves sloping upward. "Once we have accomplished that, we can pull out all the funds we need for defense activities and space. On the other hand, if we allow our productivity and our gross national product to start sliding, we'll be in for all sorts of trouble—even if there are scores of U. S. satellites and men in space."

U. S. space projects, Dr. von der Nuell insists, "cannot and will not feed the mouths of our babies. To act and believe otherwise is to be completely silly."

DR. W. T. VON DER NUELL, Chairman of Research Board, The Garrett Corp.

For that reason, Garrett's long range planning chief would like to see the U. S. scientific and engineering community concentrate more on improving U. S. productivity and perhaps devote less time and talent to space flight.

Dr. von der Nuell's philosophy, which is admittedly influenced by what he calls the "Detroit complex," nevertheless calls for a high level of spending for defense.

"Even though I don't believe we will ever get involved in a full-scale war with the Russians," he declares, "I do think we must continue to spend 40 billion dollars or more each year to maintain the deterrent to war that we now have in the Strategic Air Command."

If the U. S. could be certain there will be no hot war, the $40-plus billions could be cut down considerably, Dr. von der Nuell points out. "But I'm afraid any reduction in defense spending would be impractical and perhaps invite a military attack by Russia.

"But we're already under scientific and economic attack. We should concentrate on meeting those challenges first."

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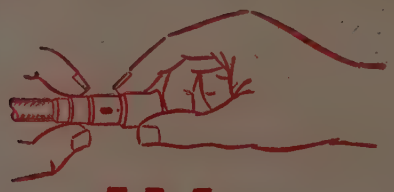

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SENTIMENT IS GROWING in Congress for a speedup in the atomic-powered aircraft program.

Joint Congressional Atomic Energy Committee, after hearing testimony by Defense Department and Atomic Energy Commission representatives, still feels the U. S. is lagging behind the Russians on development of an A-plane. Program for fiscal '60 is at the same $150 million that has been in effect for two years.

AEC reports its R&D costs on atomic engines are going down

R&D COSTS of the atomic plane and missile program have been going down, the AEC reports. Research by the AEC on the A-plane program dropped from $68.9 million in fiscal '57 to $62 million in fiscal '58. Additional drops are now expected for '59 and '60.

Despite this, USAF's Assistant Deputy Chief of Staff-Development for Nuclear Systems, Maj. Gen. Donald J. Keirn, is convinced that manned A-planes are not only possible but also inevitable. Says Keirn about the $750 million AEC-USAF investment in the A-plane to date: "We feel that we have sufficiently investigated all of our critical problem areas to the extent that we are ready to proceed with a program leading toward developmental flight testing as the next logical step."

U.S. STILL HAS NO target date for the first flight of an A-plane, although it is conceded that one could be in the air by '62 if enough pressure is applied.

Some Congressional leaders seem to be in the mood to apply pressure on the Administration by voting more funds. But the recommendations of Dr. James R. Killian, Mr. Eisenhower's Special Assistant for Science and Technology, which urge a "go-slow" approach to the A-plane, will probably prevail.

Further increase seen in weapon systems outlays

COST OF WEAPON SYSTEMS will be going up even more in the next year. But this time the inflation will not be caused by higher wages or materials prices. It will result from the imposition of state and local personal property and use taxes.

Latest development involves the introduction of a bill by Senator Strom Thurmond (D., S. C.). The measure would permit states and localities to tax any "business activity" or any person conducting such an activity.

AVOWED PURPOSE of the bill is the imposition of taxes on firms that buy materials in the name of the government and fabricate them into products that will become government property. Under this procedure, the companies involved and the U.S. avoid paying sales and property taxes.

A bill similar to Thurmond's passed the Senate last year but never got to the House floor for debate.

DOD will have to make up for contractors' local taxes

IN RECENT MONTHS, two U.S. Supreme Court decisions and actions by state legislatures have put defense contractors in several states in danger of having to pay new taxes. The price of finished products to the Defense Department will have to include these new taxes in the future.

WITH A RECORD of 22 out of 25 Polaris test vehicles successfully fired, Lockheed is projecting the launching of a complete 1500-mile missile this summer. The Navy expects to have the first submarine capable of handling the solid-propellant IRBM at sea and ready to fire in the last half of '60.

Navy is so enthusiastic about the Polaris system that it has now programed 12 subs to fire the Lockheed bird from underwater. Five are already under construction, the contract for a sixth—of advanced design—has been signed, and three more are in the '60 budget. The new budget also contains funds for the advance procurement of long-lead-time components for three more subs, which will be funded in the fiscal '61 budget.

"Building block" approach to be used by USAF on new weapon systems

USAF'S HISTORIC POLICY of creating a general operation requirement (GOR) and then having a company produce an airplane or missile to fill the need will disappear gradually over the next few years. New philosophy will use the "building block" approach in devising new weapon systems.

Lt. Gen. C. S. Irvine, AF Deputy Chief of Staff for Materiel, puts it this way: "Beyond the specific systems now being designed and de-

more on next page

veloped, it is doubtful that any of these vehicles will be completely originated as an end item in the manner of the Atlas or the X-15."

No more compromises to fit in some end items

NEW APPROACH will have scientific and economic advantages. Firms assigned to programs will be able to develop their vehicles without having to make compromises because of specific end items.

Much of the needed R&D work will be completed when a GOR is established under the new system. Production will also be speeded up, because standardized systems and components will be available.

AMONG THE AREAS scheduled to be explored in the "building block" approach are propulsion, fire control, communications, and guidance. Foremost example already underway is the Rocketdyne contract for a 1,500,000-lb-thrust rocket engine. No firm use has been established for this powerplant, but the Air Force is certain an engine of that size will be required.

The changing concept will basically mean that future planes and missiles will evolve from systems and components whose feasibility has been proved under early R&D contracts. But this will call for more funds for R&D, especially in the basic research area.

Basic U.S. research effort too low, says Bell Telephone exec

FEELING IS GROWING in Washington that the U.S. is not doing all it should in the way of basic research.

Mervin J. Kelly, board chairman of Bell Telephone Labs, believes our basic research effort should be doubled. He points out that only about five per cent of the $9 billion this country spent in 1956 on R&D (civil and military) went for basic studies.

Kelly adds, "It should be at least twice this percentage. The academic community is traditionally the home of basic research—it performs 75 per cent [of it]. Industry is next in the amount performed.

"In the interest of the nation as well as that of the industrial companies themselves, much more basic research should be done by industry. There should be a large increase in the number of companies participating as well as in the total industrial basic research effort."

SEN. LEVERETT SALTONSTALL'S bill designed to make numerous changes in Pentagon contracting procedures will not be passed by both houses as it now stands. But some of its elements will be enacted into law.

The Massachusetts Republican, ranking minority member of the Senate Armed Services Committee, has introduced S.500, which would (among other things):

- Place negotiated, competitively negotiated, and fixed-price contracts on an equal legal footing (the first two are now used as exceptions to the policy of advertising for bids);
- provide for wider use of "operational systems" procurement—an expansion of the weapon system concept of placing more responsibility in the hands of the prime contractor;
- exempt from the renegotiation procedure all fixed-price, formally advertised, and incentive-type contracts;
- lift the limitations on the use of incentive contracts and encourage these and fixed-price contracts.

Opposition to Saltonstall's proposals to come from Pentagon as well as Congress

SALTONSTALL'S MEASURE is expected to run into trouble on three counts.

- The Pentagon is expected to point out that contracting flexibility is limited by the proposals and that contracting officers need all the flexibility they can get.
- The effort to remove some contracts from jurisdiction of the Renegotiation Board has no place in Saltonstall's measure. It properly would be part of the law to extend the Renegotiation Act, due to expire June 30.
- Saltonstall's effort to put negotiated contracts on a par with advertised-bid awards will definitely be opposed by the House Armed Services Committee. Its chairman, Rep. Carl Vinson (D., Ga.), is a long-time critic of negotiated contracts.

AT BEST, Saltonstall's proposals, if finally enacted, will merely express Congressional intentions and will not be binding on Pentagon contracting officers.

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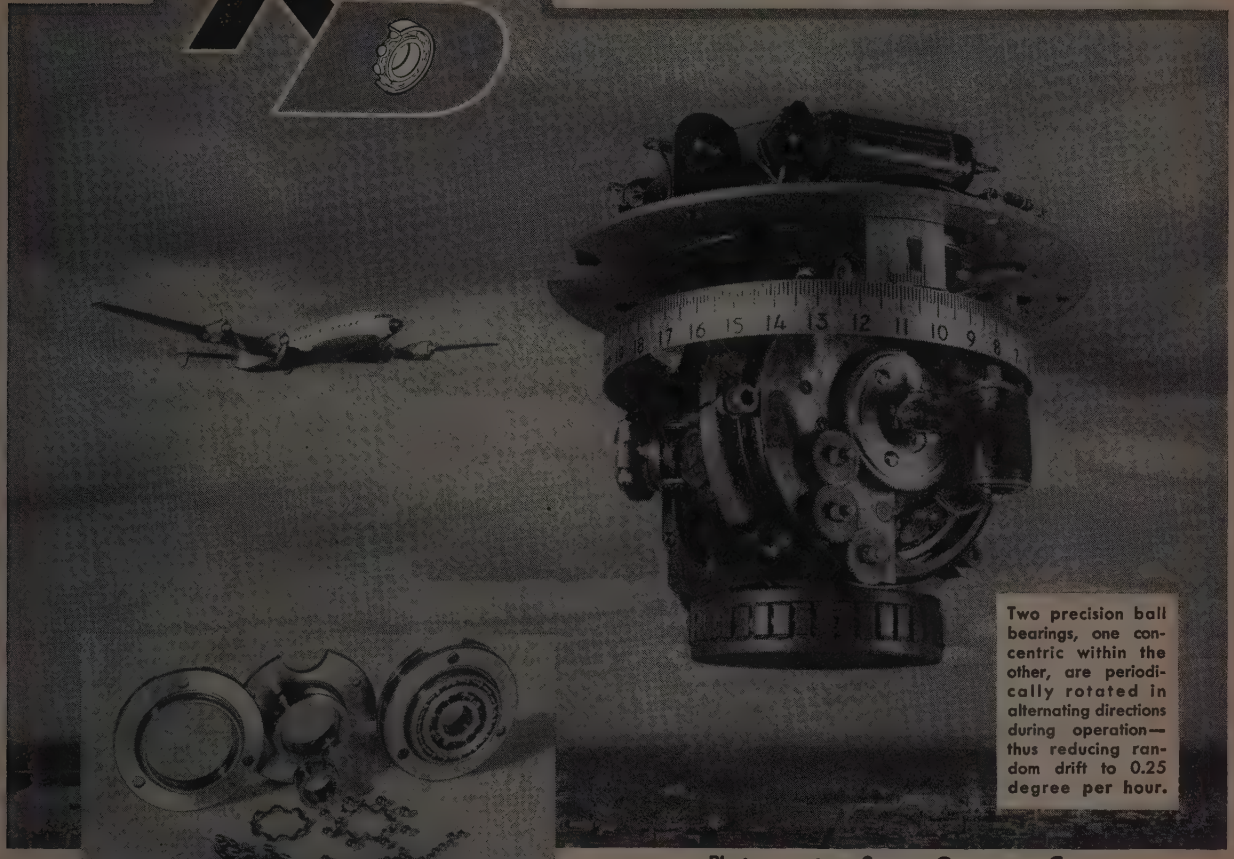
CASE HISTORIES



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LATEST DEBATE in the Pentagon and on Capitol Hill involves a Defense Department decision to delay a go-ahead on production of the Nike-Zeus anti-missile missile.

While conceding that the Douglas-Western Electric Zeus is still in the development stage, Army R&D officials think the anti-ICBM is promising enough to start production. Army feels that there is as much justification for a production run of Zeus as there is for Navy's Lockheed Polaris or USAF's Convair Atlas and Martin Titan. All three ballistic missiles were ordered into production before development was completed.

DEFENSE SECRETARY Neil H. McElroy disagrees with Army research officials, who include Maj. Gen. Dwight E. Beach, director of air defense weapons, and Maj. Gen. William W. Dick, Jr., who heads the Army's special weapons development program. He believes that there have been no major breakthroughs in the Nike-Zeus program to date and that none are likely for the near future. As much as two more years of development might be needed before Zeus output is begun, according to McElroy.

There are two other missiles in the picture, and this partially accounts for McElroy's hesitation. Convair, which is working on the long range radar needed to detect the approach of a Russian ICBM, is quietly supporting its Wizard anti-ICBM program with its own funds. And Boeing is certain that its Bomarc 2, which will have a 400-mile range, can be the basis for a solid rocket Bomarc 3 anti-ICBM.

USAF fully informed on Boeing and Convair work on anti-missile missile

BOTH COMPANIES have kept the Air Force fully informed of their research on anti-missile missiles. The Air Force in turn has made this information available to ARPA director Roy W. Johnson and to McElroy.

The DOD Secretary wants to avoid a premature production order that would have to be canceled later on because a better weapon system had become available. All three services have gone through this kind of switch during the last few years—Navy with Regulus 2, Army with Dart, and USAF with Rascal.

WINNING DESIGN PROPOSAL for Eagle defense missile was submitted by Bendix and Grumman. Bendix' Systems Division, Ann Arbor, Mich., will be responsible for system management and engineering. Bendix' Research Labs will do the electronic guidance development, and Bendix Pacific the system fabrication, missile flight control, and support equipment.

Grumman, as major subcontractor to Bendix, will be responsible for the missile airframe, propulsion, and ground handling equipment.

"Technical Staff Fellow" is new rank at RCA for top research personnel

NEW COMPANY RANK, carrying the title of "Fellow, Technical Staff," has been set up by RCA Labs to recognize outstanding individual achievement in research by Labs personnel, Dr. Irving Wolff, v-p in charge of research, reports. "We consider this appointment a badge of high technical achievement," he explains. "We hope and expect that the title of Fellow will confer the same recognition as that of Associate Lab Director and Lab Director. The difference will be mainly one of personal volition: the Fellow desiring to make continued personal technical contributions, and the Directors electing to contribute through leadership in group administration."

TITAN ICBM launching facilities are under development at both Vandenberg AFB, Calif., and Lowry AFB, Colo. Cost of each underground setup will be around $50,000,000. Vandenberg installation includes both an operational system test facility and several launch training features to break in ICBM crews. The Denver installation will be purely operational.

New minimum ICBM force is 20 squadrons

OPERATIONAL ICBM FORCE has been raised from an original 13 squadrons to a "minimum force" of 20 squadrons. The seven new squadrons will all be Titan units, each to be armed with 10 ready-to-go missiles. Originally planned ICBM forces consisted of four Titan and nine Atlas squadrons.

ARPA BUDGET of $453,000,000 for fiscal '60 is earmarked mostly for satellite work—about 75 per cent of it will go for military navigational satellites. Close to another 25 per cent will be spent on developing a defense against ballistic missiles. What little remains will go for rocket fuel research.

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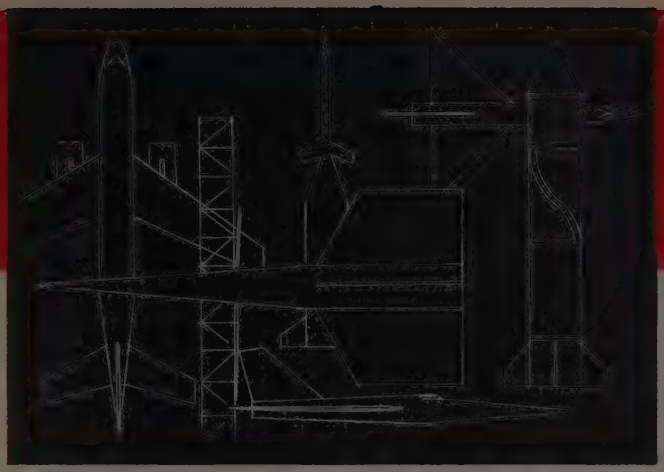

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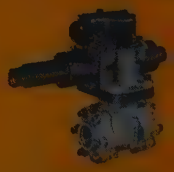

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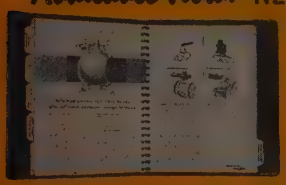

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VANGUARD II weather satellite is expected to remain in orbit indefinitely. Basic instrumentation consists of two photocells, mercury cell batteries, data transmitter operating on 108.03 mc and temperature-tracking transmitter operating on 108 mc (both with a power output of one watt), magnetic tape recorder with a 75-in. loop of erasable tape, and radio receiver.

PHOTOCELLS, developed by Perkin-Elmer, have an f/0.7 lens system with a resolution of five miles. The system includes three-inch-diameter reflecting mirror, infrared detector, and solar battery arrangement.

The two photocells are installed at fixed angles of 45 deg to the satellite's spin axis, so that one of them is always sweeping the earth (so long as the satellite does not go higher than 1700 miles).

NEXT VANGUARD LAUNCHING—slated for late this month—will again use Vanguard II's basic configuration. However, there'll be a "hotter" third stage to get up a 50-lb payload.

Turbojet and turbofan used in VTOL engine

CONVERTIBLE VTOL POWERPLANT proposed by GE Flight Propulsion Lab is designed around two basic units—a conventional turbojet and a turbine-powered lift fan. During vertical flight, hot gas from the turbojet would be ducted to a turbine geared to the lift fan. For level flight, system would be "converted" to operate as a straight turbojet.

NUCLEAR REACTOR PROGRESS rests on the development of a new family of fuel elements. According to A. Strasser, of Nuclear Development Corp. of America, only a few fuel element materials with suitable nuclear characteristics seem able to withstand the extremes of heat, radiation, and corrosion in reactors operating above 1600 deg F (the expected range for airborne reactors).

Molybdenum, niobium, and graphite look promising

REFRACTORY METALS, graphite, and possibly intermetallic compounds come closest to meeting the strict parameters of the high temperature reactors, says Strasser. Metals such as molybdenum (which melts at 4750 deg F) and niobium (which melts at 4480 deg F) also look good. Tungsten can stand higher temperatures (6100 deg F), but it also has a high cross-section for thermal neutrons.

CHEMICAL-NUCLEAR POWERPLANT combination has been proposed as solution to both ground radiation hazard and reactor shutdown heat removal. Ground support equipment in the form of mobile, auxiliary after-cooling units will still be needed for normal operations. But, in an emergency, reactor after-heat could be removed by operating the powerplant on chemical fuel to keep the air flow moving through the system.

AERIAL WINGLESS PLATFORM developed by Chrysler is scheduled for preliminary flight tests late this spring. Program will start with a series of tiedown and hovering tests. These will be followed by free flight tests to check out performance, stability, and control characteristics.

Payloads of several thousand tons to be boosted into orbit by new launcher

LAUNCH VEHICLE with high energy upper stage is being developed to boost into orbit payloads weighing several thousand pounds. Convair-Astronautics has been designated as systems manager by ARPA. It is responsible for design, construction, and test of the vehicle and all its systems except the liquid-propellant high energy engine, which is being developed by Pratt & Whitney Aircraft.

MODIFIED ATLAS will be used for lower stages. According to Convair, no basic changes will be needed in the Atlas design—only a geometric alteration of the nose area to accommodate the upper stage.

Fastener predictions: 2000 deg F and 300,000 psi

FASTENERS FOR 2000 DEG F are among major developments predicted by Standard Pressed Steel for '59. Other advances to look for, says the company, are steel fasteners with 300,000 psi tensile strength, lightweight beryllium bolts, and titanium-alloy fasteners up to 20 per cent stronger than present bolts.

HIGH TEMPERATURE fastener R&D engineers are experimenting with two refractory metals, molybdenum and niobium. Their success, says Standard Pressed Steel, hinges largely on the development of suitable protective coatings for these highly reactive metals.

more on next page

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TITANIUM BOLTS are now largely restricted to room temperature applications and 150,000 psi stress levels. Prediction is that, by the end of the year, the fastener industry will be producing titanium bolts with 180,000 psi tensile strengths and for temperatures over 300 deg F.

First transition tests in the offing for Ryan Vertiplane

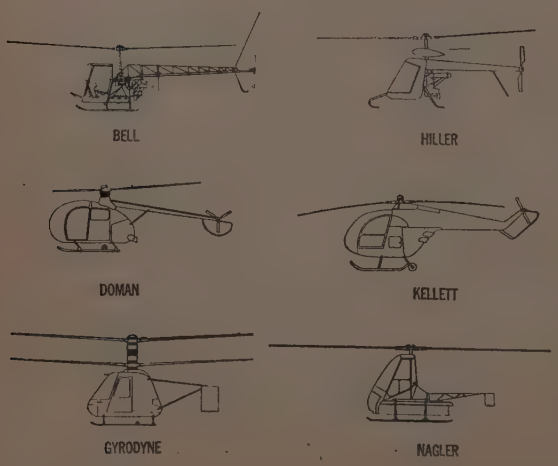
RYAN VERTIPLANE completed its first conventional flight tests. Transition tests from normal flight to low speed and hovering flight are scheduled for this spring.

STRUCTURAL MATERIAL for 5000 deg F, developed by Avco's Research & Advanced Development Division, is a reinforced ceramic. Avco will not reveal the actual nature of the material—called Avcoite—or its method of manufacture. It does say it has licked the problem of heat shock failure that has always dogged ceramic structures.

Stresses will cause deformation instead of brakes

AVCOITE is quasi-ductile and resists gas erosion. Company engineers say it will deform under excessive stresses, rather than fracture abruptly. It will also retain its shape and dimensions at very high temperatures.

Avco reports that rocket test firings have had negligible effects on nozzle throats made of Avcoite—at 5000 deg F and durations of more than 60 seconds.



VANGUARD SATELLITE DATA reveal that the earth is not as symmetrical as we believed. This finding is ranked by Dr. Robert Jastrow, chief of NASA's Theoretical Division, as second in importance only to the discovery of the radiation belt.

TRACKING TEAM found that height of Vanguard's nearest approach to earth was lower in the northern hemisphere than in the southern hemisphere. Unexpected change in elliptical orbit was not influenced by atmospheric, electric, or magnetic conditions, say the scientists. The only possible explanation, they feel, is that the earth bulges more at one pole than at the other.

Pear-shaped earth is flatter at North Pole than at South Pole

EARTH ALWAYS HAS BEEN some 27 miles flatter at the poles than elsewhere. But the new discovery shows there is also a 50-ft rise in the sea level at the North Pole and a 50-ft lowering at the South Pole. The combined effect of these variations makes the earth slightly pear-shaped.

An analysis is being made to see what, if any, effects this distortion will have on the interpretation of gravitational data recorded by experimental satellites.

RESIDUAL AIR above the earth keeps changing all the time. Air density measurements from American and Russian probe and satellite experiments show that the amount of residual air at any fixed distance above the earth varies with the season, the sun's activity, and the latitude.

Design refinements checked in latest Atlas tests

RECENT "C" SERIES of Atlas test firings is presumably meant to check out refinements in airframe, guidance system, and nose cone. "A" series was chiefly a test of the two booster engines, while the "B" series included the sustainer engine as well, plus nose cone separation and trajectory guidance.

Some observers suspect the "C" series may also include chimpanzee and other monkey shots.

ARMY WILL USE one of six configurations entered in competition for a two-place observation helicopter (see *Sideviews*). Low production cost and maintenance requirements were included among the primary design goals.

more on page 32

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TWO-TON PAYLOAD—including launching vehicle's weight—could be put into orbit by a modified Atlas. According to Dr. Herbert F. York, newly appointed Director of Defense Research & Engineering, second and third stages would have to be added to the Atlas for this feat.

Nickel, copper, cast iron are foamed to make them 90 per cent lighter

FOAMED METALS 90 per cent lighter than their solid-state forms were developed by GE's Flight Propulsion Lab. Although the technique is still in development stage, nickel, copper, and cast iron have been successfully foamed.

Potential uses for foamed metals include labyrinth seals, high temperature filters, thermal insulators, and transpiration cooling devices. Weight and strength of foamed metals are in proportion to their density, which can be controlled. Parts can be molded to shape during the foaming process or can be machined with conventional tools.

MANNED MERCURY SPACE CAPSULE will have high aerodynamic drag and be statically stable throughout its atmospheric flight regime. Capsule structure, which will be of non-lifting type, will be designed to withstand any known combination of accelerations, heat loads, and aerodynamic forces that might occur during boost or re-entry, says NASA. It will have an extremely blunt leading face covered with a heat shield.

ATTITUDE CONTROL SYSTEM use automatically positioned jet reaction controls to keep the capsule in a predetermined orbital attitude and to establish precise angle for retro-firing, re-entry, or abort maneuver. Pilot will be given option of limited manual control during orbital flight to test his willingness and ability to make attitude adjustments. Optical displays will let the pilot see portions of the earth and sky for orientation.

Re-entry to be accomplished in less than half of orbit revolution

RETROGRADE SYSTEM will be provided to supply sufficient impulse to permit atmosphere re-entry in less than half an orbital revolution after the retro-rockets have been fired. Rockets can be fired by a command data link system triggered by a ground control station or by the pilot.

PROGRAMED RECOVERY SYSTEM will be used for automatic descent. As capsule re-enters the earth's atmosphere and slows to about Mach 1, a drogue chute will open to stabilize the vehicle. At this time, radar chaff will be released to give tracking radars a good target and position fix. When the velocity of descent decreases to a predetermined value, a landing chute opens.

DESCENT PARACHUTE will be opened at a high enough altitude to guarantee safe impact on land or water. Capsule will be buoyant and stable in the water. Post-landing recovery aids will include: tracking beacons, a high-intensity flashing light system, a two-way voice radio, sofar bombs, and dye markers.

Pull rocket could separate capsule from launch vehicle; from space pilot could re-enter at will

ESCAPE SYSTEMS are provided for emergencies that might arise during the launch, boost, or orbital phases of operation. Before orbital altitude or speed is reached, a pull rocket will separate the capsule from the booster. Once in orbit, pilot can re-enter the atmosphere at any time by firing the retro-rockets.

DOWNGRADED POLARIS is said to have range of 800-1000 miles. Rather than delay the operational version, Navy reportedly is willing to trade range for immediate delivery—with the expectation that further nose cone development eventually will restore the original 1500-mile capability.

Fifteen experimental satellites this year to prepare for Sentry in '60

DOD AIMS TO LAUNCH 15 experimental satellites this year in preparation for Sentry "seeing-eye" satellite launchings next year. Broad objectives of experimental program are to develop and refine techniques for stabilizing payload equipment such as infrared, photo, and TV cameras (to remain trained on earth while in orbit), recovering of film and data tape recordings, and establishing and maintaining a controlled satellite orbit.

Atlas ICBM will be used to launch at least six Sentry satellites with minimum payloads of 3000 lb each.

more on page 34

ground-level escape!

T2J gets first successful rocket-catapulted ground-level escape system

Eighty percent of aircraft emergencies occur below 1500 feet—primarily during landing or take-off.

That is why the Columbus Division of North American Aviation—designer and builder of the Navy's T2J jet trainer—has worked long and hard to perfect a seat-ejection system that is equally effective on the ground and in the air... at stall speeds and jet speeds.

North American's new Emergency Escape System uses a rocket-catapult to hurl the seat high above the airplane—yet with minimum "G" forces on the pilot. The escape sequence is completely automatic. Timing devices are used for optimum drogue chute deployment, seat-man separation, and parachute opening.

North American's system is not only much safer than present operational systems, but also much simpler and more reliable. It is the first of this type to be accepted by the Navy Bureau of Aeronautics for use by any Navy contractor—and North American is making it available to all aircraft manufacturers as part of an industry-wide drive to insure the safety of America's pilots.

The Navy's A3J Vigilante—today's most versatile attack weapon system—will have a similar escape system, modified to provide supersonic ejection at stratospheric altitudes.

THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

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JUPITER MONKEY SHOT at Cape Canaveral successfully completed its 1500-mile trajectory. Re-entry was made, but monkey and nose cone were never recovered from the target area in the South Atlantic. Data recordings indicate the monkey underwent no appreciable physiological disturbances at any time during flight.

Monkey in Jupiter had contour-molded rubber seat pad

MONKEY WAS STRAPPED to a contour-molded silicone rubber pad for launching. (Much the same technique is to be followed in the NASA manned space capsule, in which the seat will be molded to the pilot's shape.)

Instrumentation system aboard the Jupiter test flight measured respiration and body temperature, atmospheric temperature, and pressure inside the capsule.

HIGHLY FLUORINATED ALCOHOLS may be the key to the development of satisfactory high temperature lubricants. Du Pont scientists report that the fluoroalcohols can be reacted with selected di- or polybasic acids to form esters that appear to have the required oxidation, thermal, and hydrolytic stability for high temperature operation.

Most promising compounds found so far are a fluoroalkyl camphorate and a fluoroalkyl pyromellitate. Oxidation tests on these, Du Pont says, indicate the camphorate can be used at bulk oil temperatures up to at least 400 deg F. The fluoroalkyl pyromellitate apparently extends the usable temperature range another 100 degrees.

Drawback is that at present stage of development fluoroester lubricants do not possess the viscosity and low temperature properties spelled out in tentative spec Mil-L-9236.

Better anti-sub weapons to replace Rat aerial torpedo

NAVY'S DECISION to wipe out the Rat development program stemmed from the advent of superior anti-sub weapons. Rat, developed by the Naval Ordnance Test Station, was a rocket-thrown torpedo. Launched skyward from destroyers, it was to drop to the surface by chute and then home on the submerged sub.

One of the advanced weapons that settled the Rat's fate is the Goodyear Subroc underwater-air-underwater missile. Goodyear awarded Thiokol a multi-million subcontract to design and develop the propellant portion of the Subroc missile.

"Dash" anti-sub plan combines destroyers and copters

NAVY MAY MOVE into operation of anti-sub copters from destroyers. The Dash (Destroyer Anti-Submarine Helicopter) concept is under evaluation, with the Republic-Sud Aviation Djinn copter as the sub detector.

Navy has 300 destroyers, which could be quickly converted to accommodate rotorcraft as soon as new acoustic devices now under development are perfected.

SPARROW III became the Navy's newest operational air-to-air-missile. The all-weather bird, developed and produced by Raytheon, has a guidance system developed from the Lark's and similar to that of the ground-to-air Hawk.

Most important operational characteristics are loose-aiming tolerance and all-aspect attack capability. DOD claims advanced engineering design has been combined with new packaging techniques to make Sparrow III electronics simple, small, and light. Overall length of missile is about 12 ft, diameter about eight inches, and weight about 350 lb.

P&WA JT-12 slated for three new small jet transports, may be used on drone

P & W A ' S COMPANY-FINANCED 2900-lb thrust JT-12 seems destined to be the major "small" engine for aircraft and missile applications. After USAF's cancellation of the Fairchild J83, the JT-12's only competitor is the GE J85.

The JT-12 is now slated for the production model of the North American T-39 Sabreliner, originally planned around the J85. Lockheed's four-jet JetStar will be offered for executive use with the P&WA powerplant. An alternate choice on the JetStar—also being offered as a twin-jet with Bristol Orpheus engines—"might" be the J85, according to Lockheed.

THE JETSTAR's major competitor in USAF's UCX competition, McDonnell's Model 119, was rolled out at St. Louis, Mo., and will fly first with derated Allison J33s. Four JT-12s will be installed later in the year.

FOR NORTHROP'S Q-4 DRONE, USAF will have to choose between J85 and JT-12 engines. The Q-4 was originally scheduled to use the J83.

The J85 is considered definitely set for the Northrop T-38 jet trainer and the McDonnell Quail decoy missile.

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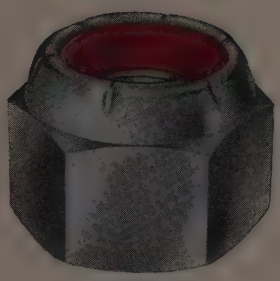

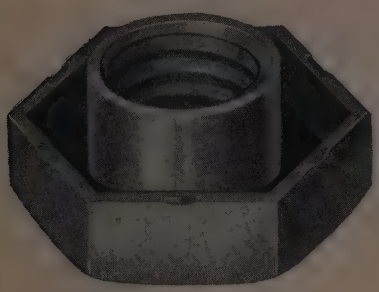

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Tantalum	5425°F	.600 lbs./cu. in.
BL2 (Tungsten Alloy)	5250°F	.668 lbs./cu. in.
Molybdenum	4752°F	.368 lbs./cu. in.
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calendar

March 3-5—1959 Western Joint Computer Conference, Institute of Radio Engineers, American Institute of Electrical Engineers and Assn. for Computing Machinery, Fairmount Hotel, San Francisco, Calif.

March 5-6—Flight Propulsion Meeting (classified), Institute of the Aeronautical Sciences, Hotel Carter, Cleveland, Ohio.

March 5-7—Western Space Age Conference and Exhibit, Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles 54, Calif.

March 8-11—Gas Turbine Power Conference and Exhibit, American Society of Mechanical Engineers, Netherlands-Hilton Hotel, Cincinnati, Ohio.

March 9-12—Aviation Division Conference, ASME, Statler-Hilton, Los Angeles.

March 10-11—Third Annual Shock Tube Symposium, Old Point Comfort, Ft. Monroe, Va. (details from Armed Forces Special Weapons Center, Kirtland AFB, N. M., R. R. Birnkoff).

March 12—Symposium on Microwave Techniques for Computing Systems, Information Systems Branch, Office of Naval Research, Dept. of Interior Auditorium, Washington D. C.

March 16-17—Conference of the Nuclear Optical Model, Office of Naval Research, Air Force Office of Scientific Research, Florida State U., Tallahassee, Fla.

March 16-20—11th Western Metal Exposition and Congress, American Society for Metals, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

March 19-20—Flight Propulsion Meeting (classified), IAS, Hotel Carter, Cleveland, Ohio.

March 23-26—National Convention, IRE, Coliseum and Waldorf-Astoria Hotel, New York City.

March 25-27—16th Annual Conference, Pacific Coast Section, Society of the Plastics Industry, Hotel Del Coronado, San Diego, Calif.

March 31-April 2—Polytechnic Institute of Brooklyn, Ninth International Symposium on Millimeter Waves, Engineering Societies Bldg., New York City.

March 31-April 3—National Aeronautic Meeting, Society of Automotive Engineers, Hotel Commodore, New York City.

April 2-3—Conference on Electrically Exploded Wires, Thermal Radiation Laboratory, Geophysics Research Directorate, Air Force Cambridge Research Center, Somerset Hotel, Boston, Mass.

April 5-10—1959 Nuclear Congress, Municipal Auditorium, Cleveland, Ohio (details Engineers Joint Council, 29 West 39th St., New York 18, N. Y.)

April 7-10—1959 Welding Show and 40th Annual Convention, American Welding Society, International Amphitheatre and Hotel Sherman, Chicago, Ill.

April 12-19—Air Force Assn., World Congress of Flight, Las Vegas, Nev.

PICTURE CREDITS: Cover, p. 4—Boeing Airplane; pp. 40-41—General Electric; pp. 42-45—NASA; pp. 46-47—Space Technology Labs, NASA; pp. 48-51—Lockheed Aircraft; pp. 52-53—S/A; pp. 54-56—Thiokol Chemical; pp. 61-65—Sperry Gyroscope, Radio Corp. of America, Brunetti, Du Mont Labs, Avco; pp. 86-97—Vickers; p. 141—Republic Aviation.

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NASA, ARPA, AEC split

U.S. space flight projects

Two independent agencies, a special Pentagon group, the three services, Presidential and DOD advisors, and a Presidential council all are deeply involved in the U.S. space flight effort. Here is a report on how their plans and responsibilities line up and how they intend to spend close to a billion dollars next fiscal year.

by Robert M. Loebelson, Associate Editor

THE THREE AGENCIES concerned with the U.S. space program are carefully laying plans for the conquest of the unexplored regions beyond our atmosphere. The group most directly concerned is the National Aeronautics & Space Administration (NASA), charged by Congress with formulating a national space program—presumably both military and civil.

NASA's budget for fiscal 1960 will total $485.3 million (plus $57.8 million for construction and equipment). Dr. T. Keith Glennan, NASA Administrator, indicates that all but about $65 million (to be used for aircraft and missile research) will go for space.

In an exclusive interview with SPACE/AERONAUTICS, Dr. Glennan pointed out that where research projects have both military and civil implications and NASA cannot get together with the Pentagon's Advanced Research Projects Agency (ARPA) on responsibility, it will be up to the President and his Space Council to determine which will have jurisdiction. "But," he added, "we really expect no difficulties in these matters."

The NASA head concedes that the Space Act of 1958 does not mention putting man into space as one of NASA's objectives. But he insists the man-in-space program is obviously one of NASA's ultimate goals.

As Dr. Glennan explains it, all of NASA's research with sounding rockets, satellites, and space probes will provide useful information for communications, meteorology, navigation and possibly for military purposes. But, he adds, NASA's real progress will be measured by the degree to which the group's work contributes man's mastery of space and knowledge about the cosmos.

For the time being, says Dr. Glennan, NASA will be responsible for the great majority of the "pure" research vehicles, coordinating its activities with Roy W. Johnson's ARPA at the technical level. "On technical aspects," he declares, "there will be a complete interchange of information between NASA and ARPA."

Military to furnish the boosters

NASA, according to Dr. Glennan, will continue to obtain most of its boosters from the military's ballistic missile projects and will concentrate on the development of second and third stages. "Adaptations of the Thor, Jupiter, Redstone, Atlas and Titan missiles will bear the brunt of space exploration launchings in this nation for the next several years," he reports.

For the future, Rocketdyne (under an ARPA-approved USAF contract) is developing a cluster of eight 150,000-lb-thrust rocket engines. This 1,200,000-lb-thrust booster is expected to be ready 18-24 months before the new 1,500,000-lb single-chamber rocket engine, which Rocketdyne is working up under NASA sponsorship. Glennan thinks four of the million-and-a-half pounders can be clustered to provide a booster with 6,000,000 lb thrust.

The problem of expanding our tracking and data acquisition capacity is well on its way to solution. New stations will be set up in this country and abroad, says Glennan. It may be necessary to man some of them with foreign nationals.

The most difficult astronautic problem, understand-

Funds for Space Activities (millions)

	Fiscal 1959	Fiscal 1960
NASA	[illegible]	[illegible]
ARPA[1]	[illegible]	307
AEC[2]	29.9	38
Total	[illegible]	[illegible]

(1) For space flight activities.
(2) For missile propulsion reactors ($22,900,000 in '59, $25,900,000 in '60) and satellite power sources ($7,000,000 in '59, $12,100,000 in '60).

NASA's Space Program (Timing Indefinite)

Soon

- Continuation of present work in physics, meteorology, space medicine, etc., with space probes and unmanned satellites.
- Exploration of earth's upper atmosphere and border of space by manned NAA-X-15 research craft.

Later

- Project Mercury—A series of brief, manned ballistic flights into space to test survival, re-entry, and landing problems.

Still Later

- Manned satellite to test navigation, communication, and survival techniques.

Much Later

- Expeditions to the moon and perhaps eventually to other planets.

ing man's capabilities in the space environment and defining the physiological and psychological conditions he will encounter, is not under NASA's jurisdiction. Space medicine remains the responsibility of USAF's Aero Medical Lab at Dayton, Ohio, and School of Aviation Medicine at Randolph AFB, Texas, the Navy's operation at Johnsville, Pa., and the military test tracks at Holloman AFB, N.M., and Hurricane Mesa, Utah. Says Glennan, "We in NASA will support military efforts in space medicine as much as we can."

Prototype contract on Mercury

Most of this space medicine work will be directly tied in with NASA's Project Mercury, designed to put a manned space capsule into orbit. McDonnell has already received a $15 million contract to produce the prototype of the Project Mercury capsule.

The McDonnell award was made on the basis of competitive bids by 12 firms. Glennan indicates many of NASA's future contracts will conform to the competitive bid patterns. (The agency has already committed more than $200 million in contracts with the space aeronautics industry.) But some future awards, according to Glennan, will be negotiated on the basis of experience and demonstrated capacity rather than on that of solicited bids.

Duplication of NASA's projects

While NASA seems destined to become the dominant Government agency in the space field, there are other groups which, at least to some extent, duplicate NASA's upcoming projects. ARPA has its own man-in-space projects, notably the Discoverer series of shots from Vandenberg AFB, Calif. This series, apparently related to the old USAF Project Sentry reconnaissance satellite, is described by ARPA Director Roy Johnson as the largest single item in ARPA's budget. First firings will be made with a Thor IRBM as the first stage. The Atlas ICBM will be used as the booster in later shots.

ARPA's total budget for fiscal '60 comes to $455 million, including the $307 million for military astronautics. But ARPA's future appears shaky, even though the President's budget message in January sought funds for Johnson's agency.

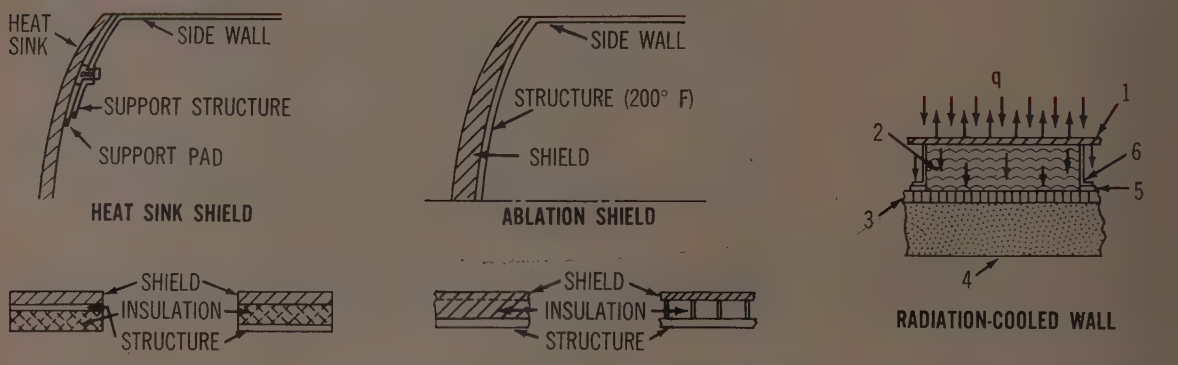
The new Department of Defense Director of Research & Engineering, Dr. Herbert F. York—who prior to this appointment was ARPA's chief scientist—is supposed to be Defense Secretary Neil H. McElroy's chief adviser on scientific projects. In that capacity, he presumably will have overall jurisdiction over military space and anti-missile programs. This could eliminate the need for ARPA.

Dr. York now over ARPA's Johnson

Nor can the personal element be ignored. Until his nomination as Director of R&E, Dr. York was subordinate to Johnson. Now he has become Johnson's superior, for the R&E director's post was defined by Congress as on a higher level than that of the former Assistant Secretary of Defense for Research & Engineering. And Johnson's ARPA at best is on a par with the offices of the other assistant defense secretaries.

The Atomic Energy Commission's projected $38 million expenditure for the forthcoming fiscal year cannot be considered duplicative in any way. AEC's work on nuclear propulsion for missiles and space vehicles will be fed to both the Defense Department and to NASA.

This then is the national space program as currently visualized by Government space planners. Under present prospects, NASA seems to be emerging as *the* U.S. space group, with ARPA apparently destined for a minor role in space. But there may still be points of disagreement between NASA and Dr. York's office even after ARPA has become a memory.—Ed



STRUCTURAL configurations for re-entry spacecraft. Radiation-cooled wall would have (1) reradiation wall, (2) radiant-heat insulation, (3) structure, (4) cabin insulation, (5) insulator, and (6) stiffener attachment.

State of the art:

Structures and materials

- **Composite structures might meet multiple requirements**
- **More structure to be applied in tension**
- **Favorable materials have low ductility**

THE ONLY ROADBLOCK in the path of space flight is time, Dr. George Solomon, director of the Astrosciences Staff at Space Technology Labs' recently told SPACE/AERONAUTICS. Technically, he notes, there aren't any problems that can't be solved. The only problems, he states, are those of deciding on the needs and of developing acceptable equipment.

A major requirement is some means of simulating the space environment. At present, it appears almost impossible to establish space design criteria with ground research facilities. L. Eugene Root, vice president and general manager of Lockheed's Missile System Div., points out that "the light, thin structures most efficient for... space conditions may not support their own weight on the ground..."

One answer, proposed by Root, is to assemble and test such structures in an orbital lab. In the meantime, the only way to gain data on them is to send up test vehicles.

A striking structural trend as we move towards manned space flight is the reduction in airframe-gross weight ratio, George Gerard of New York U. told a recent American Rocket Society meeting. This ratio, he states, has shrunk from 0.2-0.35 for manned aircraft down to 0.02-0.05 for ballistic missiles and 0.02-0.1 for spacecraft. However, says Gerard, this reduction by a factor of about 10 in the weight ratio is accompanied by an equal *increase* in the growth factor for ballistic missiles. Designing structures to minimum weight is still vitally important.

Another significant trend, according to Gerard, is a change in the way airframe weight subdivides as far as tension, compression, and shear criteria are concerned. On the average, he says, a third of the airframe structural weight of an aircraft or aerodynamic missile is governed by tension considerations, while the other two-thirds depend on compression and shear buckling criteria. In ballistic missiles, with their greater use of pressure-vessel-type structures half the weight is governed by tension and half by buckling. For spacecraft, Gerard foresees even greater use of pressurized

Ablation Shield Materials*

	Tensile Ultimate (10^{-3} psi)	Elastic Modulus (10^{-6} psi)	Fracture Strain (per cent)	Density (lb/cu in.)	Coef. of Thermal Expansion (10^{-6} in./in.-deg F)
Phenolic nylon	4.8	0.45	1.15	0.044	
Phenolic "leached" glass	4.9	2.3	0.25	0.058	
Quartz	7.1	10	0.07	0.079	0.3
Graphite	2	1.5	0.13	0.08	1.4
Teflon polymer*	2.8	0.1	5.00	0.08	55
Duroid	2.8	—	—	0.072	

*By C.W. Abbate, General Electric.

shells, and a resultant increase in the airframe weight governed by tension to two-thirds. He also notes that the proportion of airframe weight in the form of sheet products has increased from a ratio of 0.7 in aircraft and 0.8 in ballistic missiles to as much as 0.9 in spacecraft.

Design margins, Dr. R. D. DeLauer, associate director of STL's Vehicle Engineering Lab, told SPACE/AERONAUTICS, will be based on ever more rigorous testing. The trend, he feels, will be to design vehicles for particular missions, with margins of safety varying from zero in some cases to much more conservative values in others.

Re-entry and sealing are key problems

Most attention at present is being paid to the problems of sealing space cabins against leakage due to cracks or penetration by meteoroids and those of maintaining structural integrity under the extreme temperatures of entry into a planetary atmosphere. Ablation, radiation, and heat sink methods of handling airframe heat flux conditions are all under study.

The general feeling seems to be that work on heat sink and radiation is fairly well along, but that much more study is needed on ablation. As Gerard notes, space vehicle structures may have to perform sealing, re-entry protection, contouring and load transmission simultaneously. For this reason, he states, composite structural materials look promising.

For ballistic vehicles, where the heat rate is very high but heating time very low, heat sink or ablation seem best for handling the heat flux. A possible heat sink configuration was described by A. P. Coppa of GE's Missile & Space Vehicles Dept. to ARS (see *Diagrams*).

The heat shield is fastened to the support structure by a number of bolts free to move radially with the expanding shield. A layer of resilient material and insulation, Coppa states, provides a distributed contact between shield and supporting structure.

The *Diagrams* also show an ablation shield design suggested by Coppa. He notes that it's important to select materials for the main structure that avoid thermal expansion incompatibilities with the ablation layer. Because most of the good ablation materials are highly brittle, continuous shields must be bonded to the main structure. However, for temperatures in the 1000-2000 deg F range, suitable adhesives are just about unavailable. One alternate method for such regimes, Coppa states, might be to make the shield of small, relatively thin, lateral segments (tiles), relieving the shield of major thermal and load stresses.

Manned glide craft look good

For manned spacecraft, re-entry glide types look more attractive than ballistic types, NASA Ames researchers told SPACE/AERONAUTICS. A lift-type craft is exposed to much lower heating rates but, since these last longer, the total heat input is much larger than it is for ballistic types.

Radiation and/or conduction cooling looks best for lift re-entry, researchers state. From the designer's standpoint, radiation has the advantage of leaving more margin for error—weight is proportional to the fourth root of the incoming heat, whereas for the other systems it is directly proportional to the incoming heat.

NASA studies show that design tricks can greatly improve the radiation cooling approach (see *"Conduction Cuts Heating during Spacecraft Re-Entry," p. 42*). For such parts as wing leading edges, one help is to use a good radiation material and increase the thickness. Even more important, NASA tests indicate, is conducting heat back from the leading edge into cooler regions of the wing. With a 0.2-in. graphite skin, Neel notes, such reduction would reduce the leading edge temperature from 2800 to 2100 deg F.

Less ductile materials are used

Spacecraft designers will also probably have to pay more attention to ductility. In the past, most structural tension materials have had ductilities of over 10 per cent. For orbital flight regimes, Gerard told the ARS, materials such as heat-treated titanium alloys, precipitation-hardened and martensitic stainless, hot-worked die steels, and beryllium are attractive. However, these materials have ductility values ranging from 10 down to two per cent. Clearly, more research is needed on the relationship between tensile strength and ductility.

For heat sink re-entry surfaces, beryllium and graphite look more promising. Coppa states that placing the structure next to the heat sink material usually means greater structural weight but permits the use of low density installation to limit the cabin temperature. Conversely, insulation next to the sink probably would result in lower structural but higher insulation weight. As far as ablation is concerned, non-metals look most promising for shield materials (see *Table*).

Among the materials studied for radiation designs are molybdenum, graphite, beryllium, nickel, and cobalt base alloys. The first two look particularly good, but, as they have low strength-density ratios, would have to be attached to other materials acting as mainload bearing members.—End

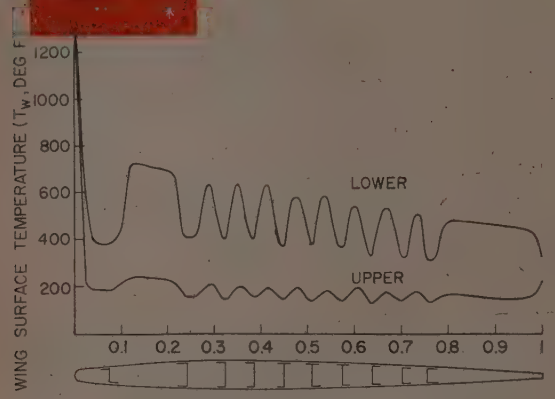


FIGURE 1: Distribution of surface temperatures of multi-web wing during pullout phase of re-entry (following a boost-glide trajectory) under transient heating.

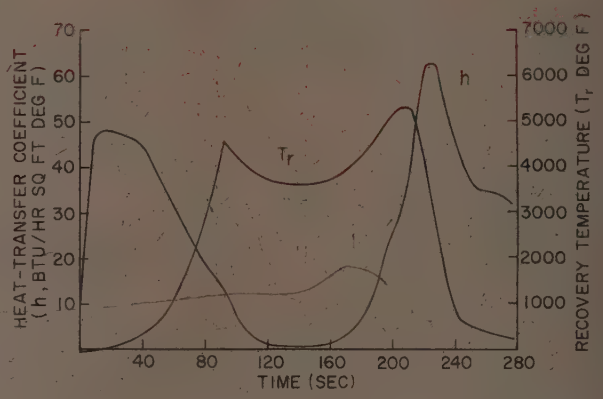


FIGURE 2: Calculated variation of recovery temperature (T_r) and heat transfer coefficient (h) at a wing leading edge with a radius of half an inch.

Conduction cuts heating during spacecraft re-entry

Extreme re-entry heating rates pose one of the toughest problems in spacecraft structure design. Recent NASA studies on wing leading edges—but generally applicable to other structural areas, too—show that conduction can sharply reduce surface temperatures and thermal gradients during re-entry.

by Carr B. Neel, Aeronautical Research Scientist
Ames Research Center, National Aeronautics & Space Administraton*

CONDUCTION appears to be a very promising way of cooling re-entry vehicles, tests at Ames indicate. An electric setup based on the analogy between the flow of heat and the flow of electricity was used to study the heating of wing structures. Electric current flow represented heat flow, voltage represented temperature, electric resistance represented thermal resistance, and electric capacitance represents thermal capacitance.

To illustrate the thermal gradients that can be generated along the surface of a wing, the temperature distribution was calculated for the wing of a vehicle under

*Ames Research Center, National Aeronautics and Space Administration, Moffett Field, Calif. This is a condensation of a paper, "Cooling of Structures in High-Speed Flight," presented to the Structures & Materials Panel of the Advisory Group for Aeronautical Research and Development, at Copenhagen (Denmark) last Oct. 20-24.

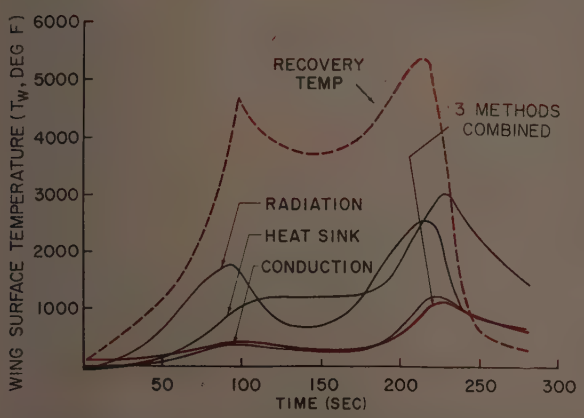


FIGURE 3: Effect of three cooling methods on wing with 1/8-in.-thick copper skin. Conduction cooling is clearly shown to be most effective.

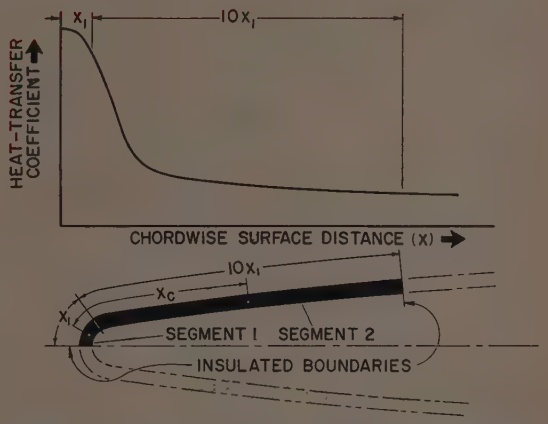


FIGURE 4: Division of wing leading edge for simplified calculation of thermal values. Segment 2 was arbitrarily chosen as 10 times longer than segment 1.

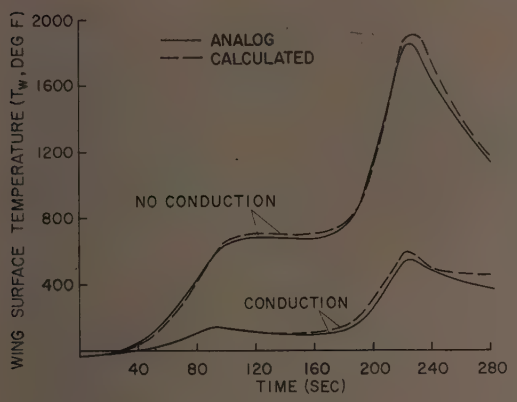


FIGURE 5: Leading-edge temperatures for 0.3-in.-thick copper skin as calculated by simplified method and as determined by electric analog.

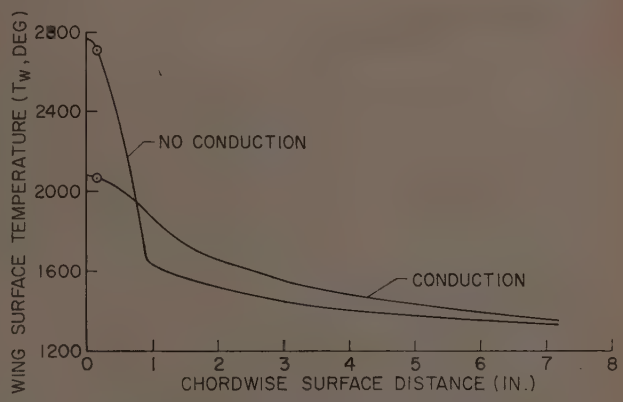


FIGURE 6: Chordwise wing temperature distribution with and without conduction for 0.2-in.-thick graphite skin at Mach 9 and 1600,000 ft altitude.

transient heating conditions in a typical boost-glide trajectory.

Figure 1 shows the chordwise temperature variation for the upper and lower surfaces of the wing during the pullout phase of re-entry.

The two most obvious features here are the high temperature at the leading-edge and the large thermal gradients along the skin. The spars, which acted as heat sinks, caused the widely varying temperatures along the wing surface. Because of the angle of attack, the lower surface became hotter than the upper, and its temperature variations were more pronounced. Such non-uniformities in temperature distribution could lead to severe structural problems, particularly under the high aerodynamic loads of the pullout maneuver.

The wing studied for the effects of radiation, heat capacity, and conduction in leading edge cooling was assumed to have a leading edge radius of ½ in. and a sweepback of 45 deg relative to the air stream. Recovery temperatures (T_r) and heat transfer coefficients (h) for the boost-glide trajectory were computed by treating the forward portion of the leading edge as a swept, circular cylinder (*Fig. 2*). The wing surface was divided into flat segments, with the local properties of air evaluated on the assumption of a gradual Prandtl-Meyer expansion downstream from the cylinder.

Our studies showed that, when cooling by radiation or heat sink was applied, the temperature fell sharply (*Fig. 3*). The greatest cooling benefit, however, was

more on next page

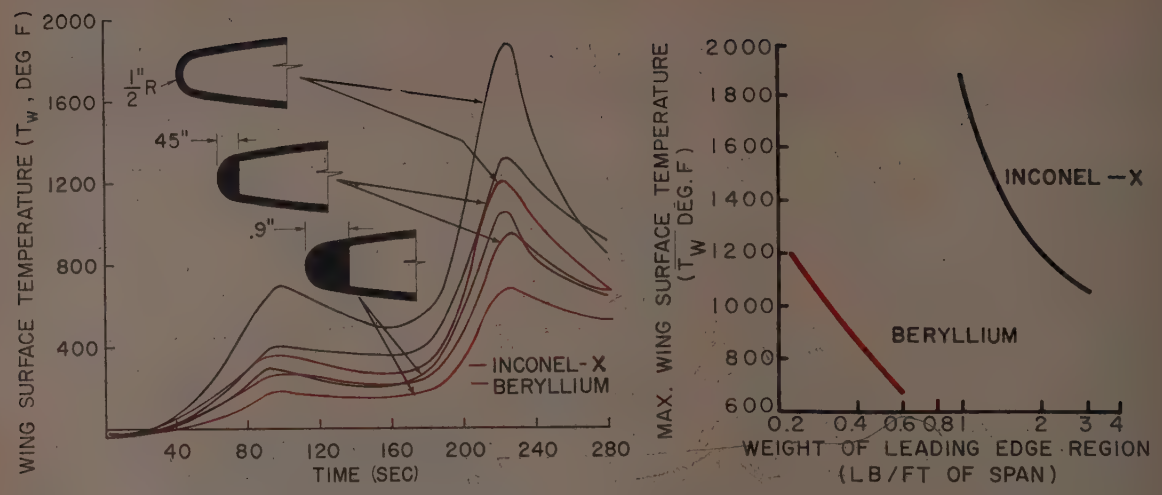


FIGURE 7: Temperature effects of additional material and material weight in leading edge area under transient heating conditions. Larger heat sink also greatly improves the cooling action.

provided by conduction—cooling provided by all three methods combined was only slightly more than that achieved by conduction alone.

Under transient heating conditions, the greatest benefit from heat sink cooling is obtained by concentrating the material in the region of the most intense heating (*Fig. 7*). A larger heat sink also greatly improves the cooling action. The heat sink material should have high specific heat and thermal conductivity if weight is to be minimized.

Simple calculations can be made

The severity of leading-edge heating makes it desirable to have a simple way of finding the temperatures it involves for various configurations under arbitrary flight conditions. Actually it's been found that, by using certain simplifications and computational procedures, leading-edge temperature histories can be approximated with relatively fast manual methods (for both transient heating and steady-state conditions).

Essentially the method involves an integrated finite difference approach. The leading-edge region is divided into two segments that are treated independently, except for a conductive correction. The flight trajectory is divided into time increments, and external heating conditions are considered constant for each of these.

Of the segments into which the wing is divided, one is much larger than the other (*Fig. 4*). The outer end of each segment is assumed to be insulated. The length of segment 1 should cover the area over which h is relatively constant. This value usually isn't critical. As a general rule, it's suggested that the aft end of segment 1 be taken as the point where h has decreased to about 85-90 per cent of the leading-edge value.

The distribution of h is computed for each time step, and average values over each of the two segments are found graphically. T_r values are treated similarly. The fineness of the division of the flight trajectory into time steps should be a compromise governed by accuracy and ease of calculation.

Two simultaneous equations, each depicting the incremental temperature rise of one of the segments, must be solved:

$$(1)\quad \Delta T_1 = (T_{r1} - T_1)(1 - e^{-\Delta\theta h_1 A_1/v_1\rho_1 c_{p1}}) - (T_1 - T_2)(1 - e^{-\Delta\theta k A_c/0.9 x_c v_1\rho_1 c_{p1}}) - T_1(1 - e^{-\Delta\theta\sigma\epsilon A_1 T_1^3/v_1\rho_1 c_{p1}}),$$

$$(2)\quad \Delta T_2 = (T_{r2} - T_2)(1 - e^{-\Delta\theta h_2 A_2/v_2\rho_2 c_{p2}}) - T_2(1 - e^{-\Delta\theta\sigma\epsilon A_2 T_2^3/v_2\rho_2 c_{p2}}),$$

where h is in btu/hr-sq ft-deg F; A is segment surface area (in square feet); v, segment volume (in cubic feet); ρ, density of wing material (in lb/cu ft); c_p, specific heat of wing material (in btu/lb-deg F); k, thermal conductivity (in btu/hr-sq ft-deg F/ft); A_c, cross-sectional area perpendicular to the heat flow path; x_c, distance between segment centroids as measured along the heat flow path (in feet); θ, Stefan-Beltzmann constant; and ϵ, radiative emissivity of surface.

The temperature rise of the segments is represented by ΔT_1 and ΔT_2 over the time interval $\Delta\theta$ (in hours). Hence:

$$(3)\quad T_1 = \Sigma\Delta T_1 + T_{1\theta=0},\ T_2 = \Sigma\Delta T_2 + T_{2\theta=0},$$

where the extreme right-hand terms are the starting temperatures.

The form of *Equations 1 & 2* results from our treatment of the heating conditions as step functions, and the values of T_r and h are those prevailing during each time step. The first group of terms on the right hand side of *Equation 1* represent the segment 1 tempera-

Sample Calculations of Wing Leading Edge Temperature*

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮
Time (sec)	T_{r2} (deg R)	h_2 (btu hr-sq ft -deg F)	0.00191③	$e^{-④}$	1 −⑤	②− ⑮ prev	⑥×⑦				⑧+ ⑮ prev	⑮³ prev	2.65×10^{-12} × ⑫ × ⑬	⑫ − ⑭ T_2 (deg R)
0														420
4	475	8.72	0.0167	0.9834	0.0166	55	1				421	0.741×10^8	0	421
8	530	8.62	0.0165	0.9836	0.0164	109	2				423	0.746×10^8	0	423
12	600	8.44	0.0161	0.9840	0.0160	177	3				426	0.757×10^8	0	426
196														736
200	5207	4.88	0.0093	0.9907	0.0093	4471	42				778	0.399×10^9	1	777
204	5333	5.73	0.0109	0.9892	0.0108	4556	49				826	0.469×10^9	1	825
208	5340	6.92	0.0132	0.9869	0.0131	4515	59				884	0.562×10^9	1	883
⑯	⑰	⑱	⑲	⑳	㉑	㉒	㉓	㉔	㉕	㉖	㉗	㉘	㉙	㉚
Time (sec)	T_{r1} (deg R)	h_1 (btu hr-sq ft -deg F)	0.00215⑱	$e^{-⑲}$	1 ⑳	⑰− ㉚ prev	㉑ × ㉒	㉚ prev − ⑮ prev	0.788 ㉔	㉓ ㉕	㉖ + ㉚ prev	㉚³ prev	2.97×10^{-12} × ㉗ × ㉘	㉗ − ㉙ T_1 (deg R)
0														420
4	485	48.8	0.1049	0.9004	0.0996	65	6	0	0	6	426	0.741×10^8	0	426
8	550	48.4	0.1041	0.9011	0.0989	124	12	5	4	8	434	0.773×10^8	0	434
12	630	47.1	0.1013	0.9037	0.0963	196	19	11	9	10	444	0.817×10^8	0	444
196														950
200	5593	26.5	0.0570	0.9446	0.0554	4643	257	214	169	88	1038	0.857×10^9	3	1035
204	5724	28.8	0.0619	0.9400	0.0600	4689	281	258	203	78	1113	1.109×10^9	4	1109
208	5760	34.5	0.0742	0.9285	0.0715	4651	333	284	224	109	1218	1.364×10^9	5	1213

* Simplified procedure for start of trajectory and for period of high heating rate. Assumptions: material, copper; skin thickness, 1/8 in., leading edge radius, ½ in., surface length of segment 1, 0.3 in., $\Delta\theta$, four seconds; ρ, 0.322 lb/cu in.; c_p, 0.102 btu/lb-deg F; k, 210 btu/hr-sq ft-deg F/ft; length of wing perpendicular to leading edge, one foot. The notation "prev" refers to the value at the previous time step.

ture rise due to convective heating. The expression $v\rho c_p/hA$ is the "time constant" of the process. The second group of terms indicates the temperature decrement due to conduction from segment 1 to segment 2. The factor 0.9 was determined empirically to give the most realistic conductive correction. The third group of terms represents the decrease in temperature resulting from radiant heat loss.

Segment 2 is treated similarly, except that conduction is ignored—It's implied that segment 2's temperature remains constant while heat is conducted into it from segment 1. In practice, segment 2 would be losing heat to the region aft of it, which would counterbalance somewhat the heat being received from the leading edge.

Simplified values compare well

In many cases, the exponents associated with convective heating and radiation loss will be small (below about 0.05) and *Equations 1 & 2* can be approximated as:

$$(4)\quad \Delta T_1 = (T_{r1} - T_1)h_1 \Delta\theta A_1/v_1 \rho_1 c_{p1} - (T_1 - T_2)(1 - e^{-\Delta\theta k A_c/0.9 x_c v_1 \rho_1 c_{p1}}) - T_1 \Delta\theta\sigma\epsilon A_1 T_1^3/v_1 \rho_1 c_{p1},$$

$$(5)\quad T_2 = (T_{r2} - T_2)h_2 \Delta\theta A_2/v_2 \rho_2 c_{p2} - T_2 \Delta\theta\sigma\epsilon A_2 T_2^3/v_2\rho_2 c_{p2},$$

The expression $(T_r—T)h$ is the convective heat flow rate (q).* The use of expressions for q is restricted to the high speeds, at which the wall temperature becomes negligible compared with T_r. In such cases, it isn't necessary to compute the individual values of T_r and h for *Equations 4 & 5*. The fourth power of the segment temperature in the radiation term is taken as $T_1 x T_1^3$ because two different values of T_1 are used in the calculation, on the basis of the variation in T_1 in successive time steps (see *Table*).

Figure 5 shows that the simplified method predicts leading edge temperatures reasonably well. Other configurations were also tried (including a wing with a thickened leading edge skin for greater heat sink cooling, a wing with a solid-copper leading-edge region, a composite wing with a graphite leading edge joined to a copper skin, a graphite wing for which variations of K and c_p with temperature were considered, and a wing with a symmetrical distribution of h), as well as other angles of attack. In each case, the agreement between simplified and analog calculations was good.

Conduction helps steady-state cases

For longer flights whose transient effects can be ignored the heat capacity of the structure will have little effect on cooling. In these cases, a vehicle not equipped with a special cooling system will be cooled only by radiation and conduction.

The temperature attained by a wing surface cooled only by radiation is governed by the convective heating rate and the radiative surface emissivity. For a wing cooled only by radiation, computations were performed on the electronic analog for Mach 9 and 160,000 ft altitude. Leading edge radius was assumed to be ½ in. and surface emissivity 0.8.

As *Figure 6* shows, for many materials radiation alone wouldn't provide enough cooling at these flight conditions. But if conduction were present, the leading-edge temperature could be greatly reduced. The conduction afforded by a 0.2-in. graphite skin, for instance, could drop the leading-edge temperature from about 2800 to 2100 deg F.—End

*Equations for q will be found in M. W. Rubesin, "The Influence of Aerodynamic Heating on the Structural Design of Aircraft;" Agard Structures & Materials Panel, Copenhagen, '58.

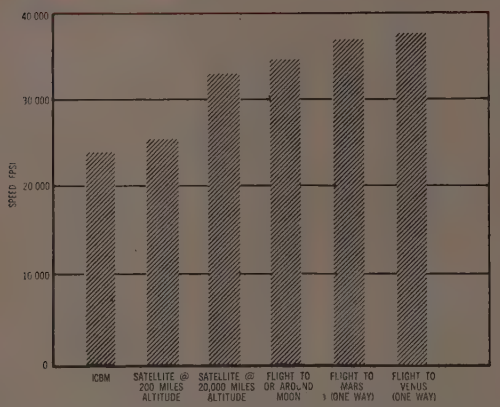


FIGURE 1: STL chart shows current ICBM speeds are almost high enough for trips to Mars and Venus.

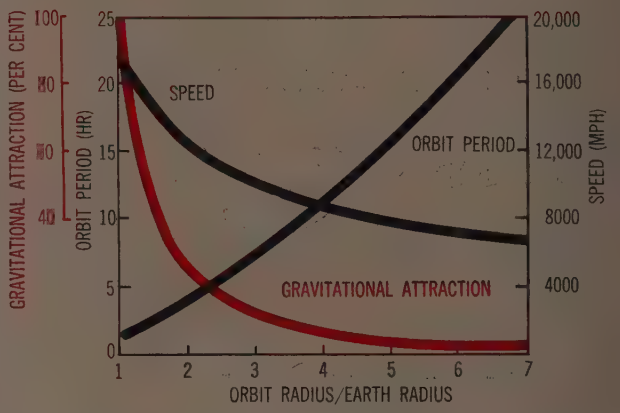


FIGURE 2: Characteristics of circular orbits as determined by NASA researchers.

State of the art: Dynamics

- **ICBMs come close to interplanetary capability**
- **Inherent damping qualities will be poor**
- **High performance test facilities are needed**

STEPPED-UP RESEARCH is the order of the day in all areas of dynamics—from high speed aerodynamics to orbit mechanics. For space travel, aerodynamics only deals with a small part of the journey. However, this area—which essentially is that of the landing problem on earth as well as on other bodies—is certainly one of the most important and critical.

The first major concern, of course, is getting the data needed to design manned spacecraft. Expanded probe and satellite programs as well as such experimental craft as the X-15 are needed to gain a better understanding of atmospheric properties. The satellites that have already been launched have given us an idea of the wide gaps in our information on the upper atmosphere. For instance, NASA reports, they indicate that the atmosphere at 140 miles altitude is about 10 times denser than expected. More work also is needed on the energy properties of air to gain an understanding of the interchange of energy between the atmosphere and a vehicle traveling at extremely high Mach numbers.

Designers will still have to lean heavily on ground test devices. It's generally agreed, Glen Goodwin of NASA Ames told SPACE/AERONAUTICS, that the conventional wind tunnel is just about obsolete as far as

space is concerned. Test facilities now are in a period of transition to setups tailored to the needs of re-entry research. Arc and shock tunnels, NASA scientists state, give the right kind of air temperatures at the right speeds, but they aren't the kind of machines you just turn on in the morning to start testing. In addition, researchers aren't sure you can reproduce the necessary kinds of escape phenomena with pressure forces.

One answer might be the use of magnetohydrodynamic devices. Electromagnetically driven shock tubes, for instance, can provide ways of propelling gases at speeds of over Mach 100.

Helium tunnels for Mach 20-25?

In the meantime, scientists are learning to combine arc setups—to heat the tunnel air—with conventional tunnels. One problem has been that carbon electrodes can lead to a carbon-contaminated atmosphere. NASA is working on eliminating this contamination and designing special nozzles to produce the desired flows.

NASA is also studying helium tunnels for the Mach 20-25 range. (These don't simulate temperature conditions.) Ames, for instance, is using colder tunnels to examine flow details over bodies and then sees if its guesses are correct by taking a quick look at the same models in an arc tunnel.

An example of some of the new equipment being built is a large shock tube nearing completion at Ames. I thas a 27-ft-long combustion chamber made from a piece of a 26-in. naval gun. The shock tube is 40 ft long and includes a 10-ft test chamber. The vacuum tank is about 12 ft long. Scientists expect to get heat transfer data for satellite re-entry for flows of 16,-18,000 fps for 1/10 seconds. With more sensitive thermocouples, they eventually hope to get 40,000 fps for 100 seconds.

NASA has an atmosphere simulator

Ames also has a large atmosphere re-entry simulator that will soon be in operation. The model is fired from a helium gun into a large end of a long, trumpet-shaped nozzle. High pressure air is blown into this nozzle at its smaller end. The diverging walls cause the air to expand, so its density decreases as does that of the atmosphere. For proper simulation, the model must fly at the same initial speed as the full-scale vehicle.

By substituting suitable gas mixtures, flight through atmospheres of other planets can be simulated. The nozzle section of this tunnel is 40 ft long and goes from a section of 6x6 in. at one end to 4x4 ft at the other.

One of the problems facing the aerodynamicist is that satellites and space vehicles will have much less damping than aircraft, NASA reports. The body shapes needed to overcome re-entry heating presently appear to be inherently unstable. Blunt, stubby spacecraft, NASA states, have such poor damping qualities that they'll tend to diverge from a steady course. They will need "every possible design refinement plus artificial stabilization to accomplish controlled flight in the atmosphere."

Aerodynamic heating, researchers report, has eliminated the advantages of flying at close to zero angle of attack. A re-entry vehicle, it seems, should come in at high angles of attack to gain as much lift as possible—which will keep it high in the atmosphere while it slows down.

Blunt shapes must be modified

Designing a manned re-entry craft again brings in the inevitable need for aerodynamic compromise. A blunt shape, as NASA's Allen showed, pushes the air ahead of the re-entry body, forming a strong shock wave in which much of the heat is dissipated. However, for greater lift, the vehicle must become more flattened out—and then less blunting can be tolerated. Deceleration is thus increased but so is the heating problem.

One answer, researchers suggest, might be vehicles with variable lift-drag ratios that would re-enter without lift but with high drag provided by a braking device. When the speed has dropped low enough, the drag device would be jettisoned or retracted, leaving a lift device for the final landing stages.

Speed is the key to spaceflight

One of the interesting aspects of orbit mechanics is the importance of velocity, Dr. Paul Dergarabedian, associate manager of the Vehicle Systems Dept. at Space Technology Labs' Astrovehicles Laboratory, told SPACE/AERONAUTICS. Our current ICBM designs, he notes, come very close to meeting the speed requirements of extended space flight. Actually, only a little more speed is needed for flights to Mars and Venus than for trips to the moon. (*Fig. 1*)

In some cases, Dergarabedian points out, satellite orbits will require higher performance than for simple escape into space. To place a satellite into orbit at 50,000 miles altitude above the earth, for instance, the boost vehicle must coast to a certain point and then fire an extra stage—which means carrying added dead weight of fuel during coast.

A polar satellite orbit has the advantage of carrying the satellite over all parts of the earth. Circular orbits (instead of the elliptical ones achieved so far) also have points in their favor (*Fig. 2*). NASA has suggested a satellite following a circular orbit around the equator at 22,000 miles altitude. This satellite would complete its circle once every 24 hours and so appear "stationary," and if there were two other, equally spaced satellites in the same orbit, they could all be equipped with relay equipment for worldwide radio and TV.

Accurate guidance equipment can greatly simplify the design problem for interplanetary flight. It would get the designer out of one of today's worst quandaries: whether to use a minimum-energy trajectory, which makes the course very velocity-sensitive or go to higher speeds, which reduce the trajectory error but also cut down the payload.—End

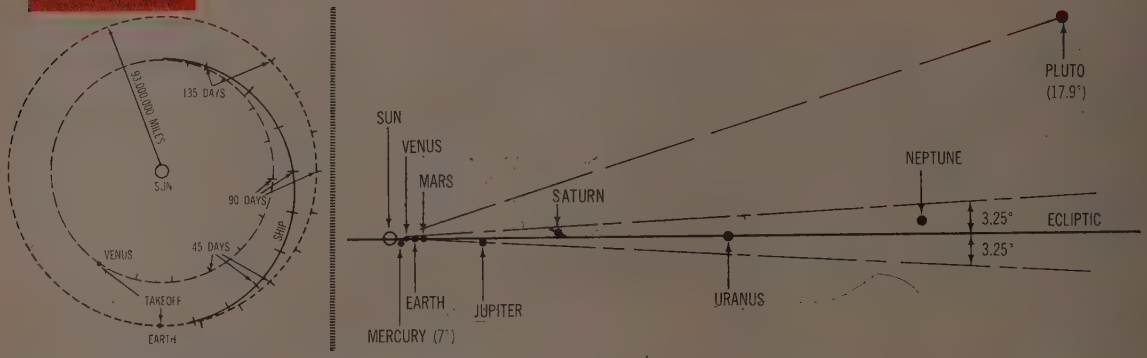


FIGURE 1: Minimum-energy trajectory from earth to Venus (left), which probably would have to be followed by any spacecraft based on the present state of the art. It requires the minimum change in energy, or velocity. Right: Navigation within our solar system can be considered as confined to the ecliptic plane of the earth's rotation about the sun—only Mercury and Pluto are substantially outside this plane.

Accurate position data needed for

space course changes

Spacecraft dynamics essentially depend on two factors: engine power and navigational accuracy. How the two interact is shown in this discussion of interplanetary trajectories at various energy levels.

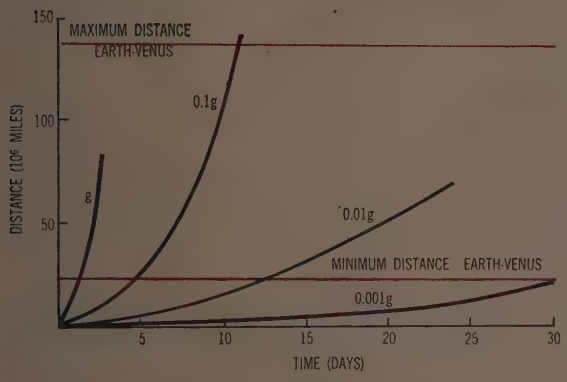
by E. V. Stearns and W. E. Frye,

Manager, Requirements Evaluation, and Manager, Guidance & Control Develoment, Missile Systems Div., Lockheed Aircraft Corp.*

AT THE PRESENT state of the art, any early interplanetary vehicle will probably have to follow a minimum-energy trajectory (which would require the smallest change in energy—equivalent to velocity for present purposes—in order to cause a space ship to enter the orbit of the destination planet). In addition, the launching would have to be precisely timed so that, on arrival, the craft would coincide with the orbit of the destination planet and be "captured" by it.

The minimum energy path to, say, Venus, is an ellipse whose major axis is a straight line from the earth's position at the time of departure through the sun and to Venus' position at the time of arrival (*Fig.*

*Missile Systems Div., Lockheed Aircraft Corp., Sunnyvale, Calif.



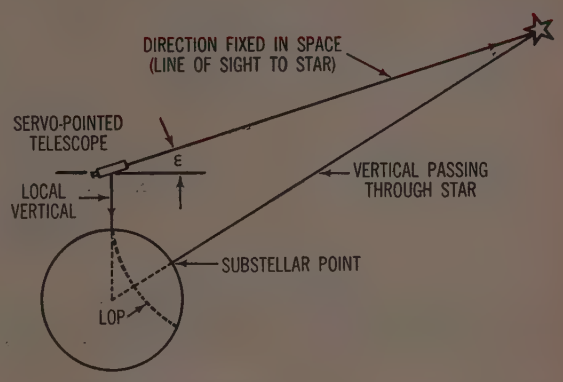


FIGURE 2: High energy trajectories between the earth and Venus (left) for various accelerations. Time of trip also depends on relative location of the two planets at takeoff. It's assumed thrust is accelerating half the way and then decelerating, with the net acceleration along the line of flight, and that the straight-line trajectory for the maximum distance doesn't enter Mercury's orbit. Right: Celestial sight to obtain line of position (LOP).

1). The properties of the ellipse can be described as:

$$\textit{Semi-major axis} = 1/2\,(R_F + R_N) = a,$$

$$\textit{Semi-minor axis} = \sqrt{R_F R_N} = b,$$

where a and b are the semi-major and semi-minor axes, respectively, and R_N *and* R_F are the distances from the sun to the far planet at the time of departure (or arrival) and to the near planet at the time of arrival (or departure), respectively.

If this path is used, the spacecraft's orbit is established by the launching conditions, and cause changes can only be made during the thrust interval of several minutes. Because of the properties of the ellipse and the fact that the orbit chosen by the guidance system must have the sun at one focus, the small guidance errors that will occur aren't intolerable. They merely introduce a requirement for a terminal maneuver of the same order of magnitude as the error in guidance.

Once solar, ionic, nuclear, or similar engines have become efficient enough to maintain relatively high thrust levels over a major portion of the flight, the picture will change. A spacecraft's trajectory under these conditions can be obtained by integrating the differential equation that sums the accelerations acting on the craft:

$$\ddot{\underline{R}} = \underline{g} + \underline{b},$$

where $\ddot{R}$ is total acceleration; g, acceleration due to gravity; and b, non-gravitational acceleration (due to thrust).

Once the ship has escaped the local gravitation of the earth, the gravity to be reckoned with is that due to the sun (*Table III*). We will assume here that the thrust accelerations are of the same order of magnitude and that they can be sustained over intervals comparable to the time of flight.

Table II and *Figure 1* show that, to a fair degree of accuracy, navigation within the solar system can be

more on next page

Table I: Mathematical Orbit Relations

Equations of motion:

$$\ddot{\underline{R}} = \underline{g},\ \ddot{x} + \omega^2 x = 0,\ \ddot{y} + \omega^2 y = 0,$$

where $\underline{R}$ is geocentric radius vector; ω equals $g_o R_{o2}/R_3$; x and y are components of $\underline{R}$; and g is gravity, equaling $\underline{R} g_o R_o^2/R^3$.

Energy of motion: $E = GmM/2a$,
where G is gravitational constant; m, mass of particle in orbit; M, mass of sun; and a, semi-major axis of orbit.

Integrated equations of motion:

(1) $r = a\,(1 - \epsilon^2)/(1 - \cos\theta)$, **(2)** $x = x_o \cos\omega t + \sin\omega t \dot{x}_o/\omega$,

(3) $y = y_o \cos\omega t + \sin\omega t \dot{y}_o/\omega$,

where Equation 1 uses the energy assumption and constant angular momentum; Equations 2 & 3 use initial conditions; ϵ is orbit eccentricity; θ, angular position of particle in plane of orbit; ω is assumed constant; x_o and y_o define the point of entry; and $\dot{x}_o$ and $\dot{y}_o$ define the velocity of entry.

Orbit eccentricity: $\epsilon = \sqrt{1 - b^2/a^2}$,
where b is the semi-minor axis.

Orbit period: $\tau = 2\pi a^{3/2}/\sqrt{GM}$.

Angular rate: $\dot{\theta} = 2\pi(1 - \epsilon\cos\theta)^2/\tau(1 - \epsilon^2)^{3/2}$.

Table II: Sun's Gravitational Field

Distance from Sun (miles)	Orbit	Gravity Due to Sun	
		Ft/Sec²	g
142,000,000	Mars	0.0084	2.6×10^{-4}
93,000,000	Earth	0.0194	6.1×10^{-4}
80,000,000	.....	0.0255	8×10^{-4}
67,000,000	Venus	0.0380	1.19×10^{-4}

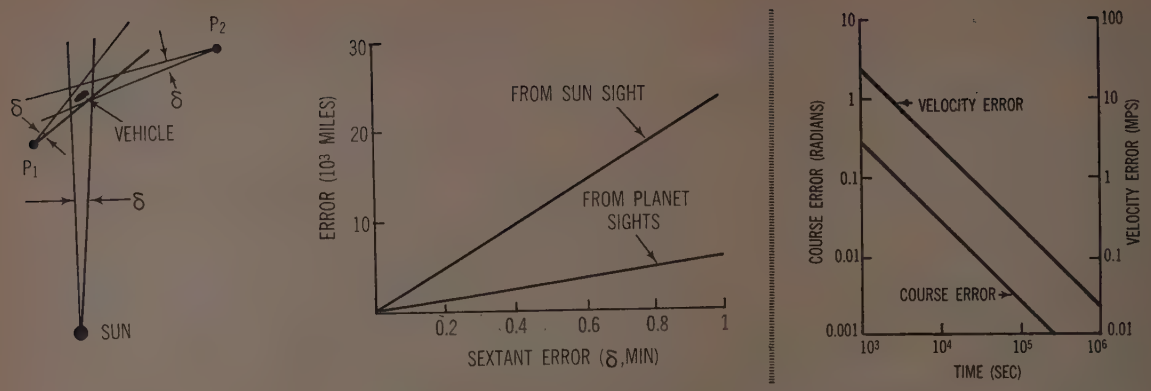


FIGURE 3: Results of typical error calculations (left) for earth-Venus trip. Distance of 80,000,000 miles to sun and average distance of 20,000,000 miles to each planet are assumed. Right: Accuracy of results of successive position measurements. After about 188.8 hours, heading error may be cut to 0.5 milliradians.

considered as confined to the ecliptic plane (of the earth's orbit about the sun) and the major planetary orbits as circular (excluding Mercury and Pluto). Equations of motion can be used to specify planetary orbits and the trajectories of interplanetary vehicles. For purposes of guidance or navigation, these are most useful in forms derived in terms of the initial conditions—position and velocity of the craft when it enters its free-fall orbit (*Table I*).

The trip has three main phases

The time needed for high-energy interplanetary transits depends on the acceleration program and the distance traveled. The latter in turn depends on the relative locations of the planets at the time of takeoff (*Fig. 2*).

The trip consists of three major phases:

- *ascent* or exit from earth's atmosphere;
- the *midcourse* phase, during which navigation over the immense distances of interplanetary space are navigated and which, we'll assume, ends in a near-satellite orbit about the destination planet, from which a landing site can be selected;
- *landing,* during which the large kinetic and potential energies in the orbiting vehicle are dissipated.

We will concentrate here on the problems of the mid-course phase proper.

Figure 2 shows the method of determining the position of a vehicle on earth by celestial means. The navigator making his star sights uses the earth's gravity as his reference in measuring angles of elevation. In this way he could actually track the direction of his local vertical as he moves about the earth. To mechanize this triangle, we need (1) an airborne stable vertical (artificial horizon), (2) a (gyrostabilized) reference fixed relative to the stars, (3) computation equipment, and (4) a star catalogue or its equivalent in computer storage.

For an interplanetary vehicle, the measurement of the direction to a star must be made with reference to some convenient datum line. The reference used here is the heliocentric gravity direction as indicated by the line of sight to the sun.

Sights to distant stars don't aid in position determination since, unlike the earthbound navigator, the space navigator isn't restrained to the surface of a sphere. In the absence of parallax, as in the lines of sights to distant stars, star sights only establish the direction of the reference line on the celestial sphere; they do not establish the navigator's position along that reference. Added star sights won't resolve the ambiguity, since (loosely speaking) the distant stars present the same pattern to an observer located anywhere in the solar system.

The ambiguity *can* be removed by:

- measurement of the angle subtended by the sun's disk,
- measurement of the characteristic time and forced error of a stabilized indicator of the heliocentric vertical as referenced to a sun sight,
- use of planet sights and the resultant parallax.

The first method isn't sensitive enough to be useful. The second will serve in principle, but it isn't practical —the time needed for it approaches that of a complete orbit. The most useful method of establishing positions in the solar system is planetary sights.

Since each sight represents a line in the plane of the ecliptic, a determination of a position (or point) requires the intersection of two known lines (or sights). The configuration of the solar system is known at all times; thus the sun and planets may be used to provide these sights.

Following terrestrial practice, three celestial sights will be used to find the craft's position. The accuracy with which this fix can be made depends on the vehicle's distance from these celestial bodies.

Figure 3 shows the results of typical calculations. For our example, if a sextant of 0.5 minute error is used, the position measurement is in error by about 12,000 miles in the direction perpendicular to the line of sight to the sun and by about 3000 miles in the direction perpendicular to the lines of sight to the two planets.

Table III: Planetary Data

	Mean Distance from Sun		Orbit Period (years)	Orbit Eccentricity	Inclination to Ecliptic (deg)	Stellar Magnitude	Mean Velocity in Orbit (mps)
	Astronomic Units	Miles					
Mercury	0.387	36,000,000	0.2	0.206	7	—1.2	30
Venus	0.723	67,200,000	0.7	0.007	3.24	—4.4	22
Earth	1.000	93,000,000	1	0.017	0	.....	18.5
Mars	1.524	141,500,000	1.9	0.093	1.51	—2.8	15
Jupiter	5.203	483,300,000	11.9	0.048	1.18	—2.5	8
Saturn	9.539	886,100,000	29.5	0.056	2.29	—0.4	6
Uranus	19.182	1,783,000,000	84	0.047	0.46	+5.7	4
Neptune	30.058	2,793,000,000	164.8	0.009	1.46	+8.8	3
Pluto	39.518	3,675,000,000	248.4	0.249	17.9	+15	3

Velocity may be obtained from two such measurements and the elapsed time. It will be in error according to the uncertainty in position measurement and the time between measurements (*Fig. 3*). To obtain order of magnitude estimates of these uncertainties, the error in velocity from two successive measurements has been simply taken as:

$$V_S = 2\sigma_s/t$$

where σ_s is the position uncertainty perpendicular to the line of sight to the sun (which is along the velocity vector) and t is the time between measurements. Similarly, course error can be estimated as

$$\tan \beta = 2\sigma_p/vt,$$

where σ_p is the position error perpendicular to the line of sight to the planet and v is the heliocentric velocity of the vehicle (perpendicular to the line joining the vehicle and the sun).

After 680,000 seconds (about 188.8 hours), errors are reduced to about one per cent of the difference between the heliocentric velocities of the earth and of Venus, or 0.035 mps. Over the same time, heading errors may be cut to about 0.5 milliradians.

The fuel consumed in changing course may be estimated by equating the thrust force obtained from fuel burned to the force needed to obtain a change in vehicle momentum:

$$T = \dot{W} I_{sp},$$

where T is thrust, equaling $MV d\beta/dt$; $\dot{W}$, rate of fuel consumption; and I_{sp}, specific impulse.

Solving the resulting differential equation gives the curve of *Figure 4*, under whose conditions about 0.7 per cent of the vehicle weight must be used to make a 0.5-milliradian heading correction.

Position data must be accurate

This very rough calculation shows that the accuracy of position data in interplanetary travel is very important. For example, if a fixed proportion (f) of vehicle weight is used at specific intervals, the total weight so used may be estimated from:

$$W = fW_o \Sigma^n_1 (1 - f)^{n-1},$$

where n is the number of elapsed intervals. For f=0.7 per cent and n=16 (corresponding to 140 days at 200=hr intervals), the fuel consumption is:

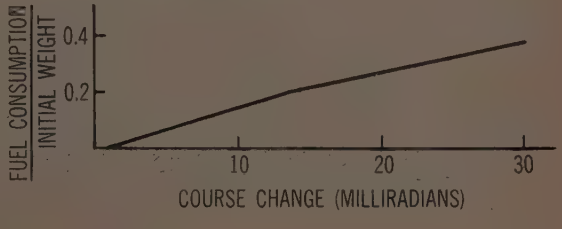
$$W \approx W_o [(n - 1)f] = 0.105 W_o.$$

This represents a large amount of fuel when one considers that fuel for landing and return must also be carried. In view of the linear nature of the problem, we can estimate that, if the sextant were mechanized and its uncertainty reduced by an order of magnitude to, say, 0.05 minutes, W would be similarly reduced and drop to $0.01W_o$.

One possibility would be to attempt no course changes until near the final approach. For a one-milliradian error in heading on a flight of about 150,000,000 miles, one would drift off course by some 150,000 miles. If the correction were applied with 5,000,000 miles to go, about 40 per cent of the vehicle gross weight would be needed to make this single change. New fuels with much higher I_{sp} will, of course, improve this performance.

The linear nature of the problem also applies to the reduction of smoothing time. In our example, the earth-Venus transit took about 14 days. A 190-hr smoothing time wouldn't be good here. Cutting both smoothing interval and sextant error by a factor of 10 would produce no change in the navigation error. Here, too, the fuel used to make course changes in 14 days would be $0.105W_o$.—End

FIGURE 4: Fuel consumption (W) during course changes of a rocket-powered space vehicle with a specific impulse of 240 seconds. W equals $W_o(1—eV\beta/I_{sp}g)$.



State of the art: Propulsion

- **Ion and nuclear engines several years off**
- **More rocket chambers to be clustered**
- **High altitude ignition designs needed**

THE COMMON ELEMENT of today's design trends in spacecraft propulsion systems is a tendency toward simple and proven components. Fewer powerplants are being tailored to a single mission, and designers have begun looking for standard components applicable to a wide range of engines.

Among the overall trends, the most important are:

- clusters of rocket thrust chambers in the place of the single, large chamber;
- accurate burning control (either by telemetry or by integrating accelerometers);
- accurate loading and pressure determination to keep mixture ratio control to a minimum;
- overdesign that allows changes in thrust level and/or burning time;
- more engine flexibility for control purposes, achieved by gimbal mountings using very high pressure hose.

Almost all the big liquid rocket thrust chambers today are tube bundles. The tubes, which carry one of the propellants as the coolant, are brazed or welded together and wire-wrapped or cast into aluminum to provide pressure sealing.

Welding is critical on these designs, and considerable pressure testing is necessary. Chamber materials vary from aluminum for the 5000-20,000-lb thrust range to copper, nickel, and stainless for thrust levels up to 200,000 lb.

The injector, the most critical element of the chamber design and decisive for mixture ratio and burning efficiency, has settled into a fairly conventional pattern of impinging jets. With development costs for this unit running into hundreds of thousands of dollars, it has become necessary to abandon the many paper designs engineers used to play around with and fall back on the one injector design that has actually worked out in the majority of cases.

Sweat and film cooling are still taking a back seat to the conventional regenerative method. Occasionally, though, chambers have small holes drilled in critical areas—such as the throat—in which a little extra cooling is needed. Advanced work on sweat and film cooling is being done at Jet Propulsion Lab, Ohio State U., Purdue U., Rocketdyne, and other facilities.

The rapid but non-explosive starting and shutdown transients required by rocket chambers often are determined by the location of such flow control elements as the propellant shutoff valves. Several engines have had at least one of these valves (usually for the oxidizer) built right into the injector. This gives accurate control of flow start and shutdown—though at the expense of design problems in the complicated back part of the injector.

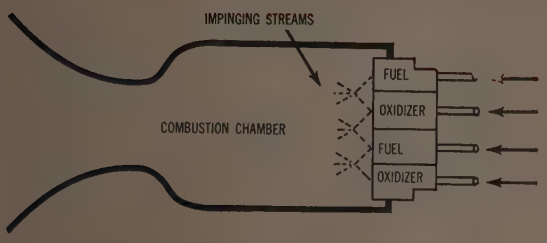
Today's rocket pumps are still the usual high speed centrifugal units driven by a gas generator. The gas comes either from the breakdown of hydrogen peroxide or, more commonly now, from the combustion of some of the normal propellant store. In the latter case the designer must find a way of burning part of one of the propellants in a separate chamber in which a "low order" combustion process can take place.

Power takeoff from pump or shaft

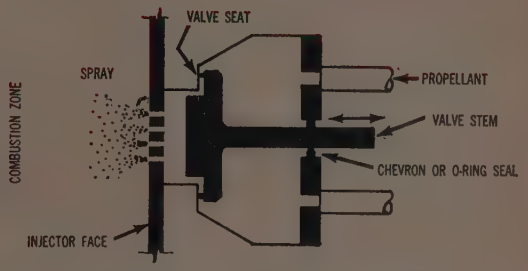
The use of power takeoffs from the gas turbine or the pump shaft for auxiliary systems is becoming increasingly important. There is also a trend toward the use of the turbine exhaust gases for roll control. Diverting these gases to side ports in the vehicle skin calls for high temperature piping, leakproofing, and highly reliable nozzles.

Much the worst pump design problem is sealing. With new propellants such as hydrogen and fluorine, shaft seals are more critical than ever before. For pump and other seals, several important new materials have been developed over the last 2-3 years, among them new fluorinated plastics and sintered copper and titanium alloys.

In tank design, it's becoming an accepted practice to use segments of large tanks to make up smaller combination tanks. For instance, a good tank can be fabricated by taking the two hemispherical domes of a larger tank and welding them together into a sphere,



INJECTOR DESIGNS using impinging propellant streams are being favored for liquid rockets.



VALVES are being built into injectors for accurate control of propellant flow start and shutdown.

which then can be used in a smaller rocket engine.

Large vehicles such as spacecraft will be kept structurally rigid by the tank pressure (needed to provide a positive pressure head at the pump inlet and usually something like 50 psi). This approach has actually proved out on the Atlas ICBM.

Solid propellant charges are widely used for tank pressurization. They involve only a small weight penalty, since they rely on chemical action. They complicate the plumbing design, though, because of their high temperatures and the presence of solid particles, which require filters. Seals and lubricants must also be found that will withstand the decomposition process, and locating the charges in the environment of a pressurized sphere is not always easy.

Helium saves weight over nitrogen

Helium is still the standby for pressurization. It is expensive and tends to leak, but it saves the designer at least one-third of the weight he would need for an equivalent nitrogen system.

Current tank materials for use with corrosive propellants are 410 stainless and aluminum alloys (such as 61S). Because of its high strength, 410 is also used with non-corrosive propellants. Over the next few years, lightweight stainless steel tanks undoubtedly will predominate, with aluminum in second place.

A new area of interest today is the high altitude ignition of rockets burning non-hypergolic, or non-self-igniting, propellants (such as liquid oxygen and jet fuel). Spark and glow plugs will not accomplish this job, and some other means—such as a small auxiliary combustion chamber—is needed.

Re-ignition at altitude in X-15

Another problem is the repeated re-ignition of rockets at high altitudes with hypergolic as well as non-hypergolic propellants. A good example is the ammonia-oxygen powerplant of the North American X-15, which must be under the pilot's control at all times. For manned space flights, rockets throttling is equally important. Considerable experience has been built up in this area through the use of segmented injectors.

The use of such "conventional" liquid propellants as liquid oxygen (LOX), peroxide, nitric acid, and unsymmetrical dimethyl hydrazine will continue for quite some time. Flow controls that won't freeze occasionally in LOX service have yet to be found. For nitric acid, the critical requirement is chemically inert seals (of Teflon, Kel-F, or the like).

The big liquid propellant news recently was the award of a contract for a hydrogen-oxygen engine to Pratt & Whitney Aircraft. Designers will have to face up to the troublesome problems of containing hydrogen at low temperatures in its liquid form and of sealing it in its gaseous form. The hydrogen embrittlement of metals also will become a factor.

Simpler designs will become possible in the wake of another new propellant development—the use of stable and storable types such as N_2O_4. With these, expensive stainless storage tanks and jacketed vacuum vessels will no longer be necessary.

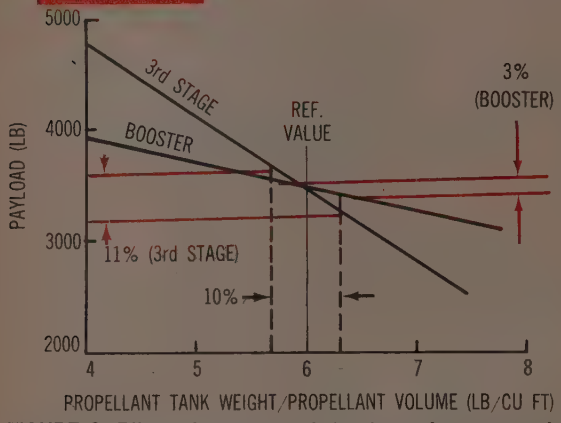
Controllable solids are studied

In solid propellant rocket design, attention is centered on the problems of movable and controllable engines. Swivel nozzles, jet vanes, or similar devices can be used to change the direction of the rocket exhaust and so of the entire craft. Since these control elements take a beating in the rocket flame, materials such as molybdenum, graphite, and titanium must be used.

New materials such as fiberglass plastics and highly stressed steels (4130 and the like) are improving the mass ratios of solid rockets. As the use of solids increases in large vehicles, the packaging of APUs, and hydraulic and pneumatic systems for ready installation in the restricted areas of solid propellant cases is being considered.

The use of ion engines is still some time off. At first, it will be limited to small units for the attitude stabilization of interplanetary craft. Within the next five years, though, an ion engine developing 5-10 lb thrust should be in use on deep space probes with a gross weight of about 500 lb.

In nuclear propulsion, too, the practical hardware stage is still some time off—at least two years. The main design problems here are shielding and the heat exchangers.—End



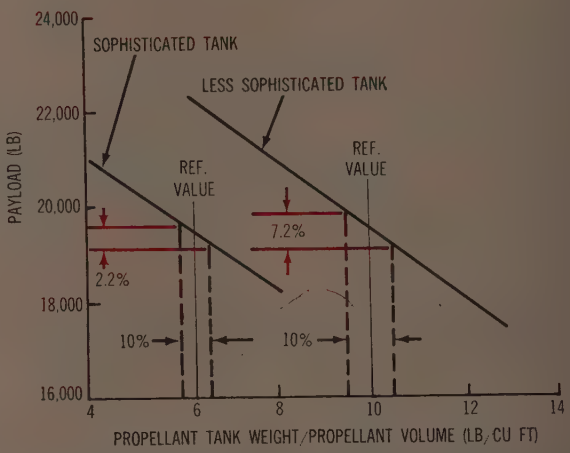


FIGURE 1: Effect of escape craft hardware improvement (left) for first, or booster, stage (I_{sp}=270 sec, R=2.8, ΔV=5200 fps, T/W=85) and third, or top, stage with I_{sp}=313 sec, R=6.7, ΔV=19,200 fps, T/W=100, where I_{sp} is specific impulse; R, mass ratio; ΔV, speed increment; T/W, thrust-weight ratio. Right: Effect of reference value on importance of hardware in orbital top stage (I_{sp}=313 sec, R=2.8, ΔV=10,500 fps, T/W=85).

Choosing rocket parameters:

High specific impulse vs lightweight hardware

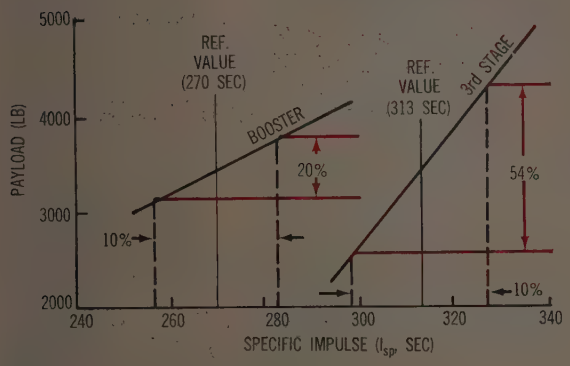
To add even a second to the specific impulse or cut the hardware weight by a few pounds takes a lot of effort. To the spacecraft engine designer, it's of the first importance, therefore, to know which will do him more good in terms of performance.

by William J. Reinhardt,
Supervisor of Technical Planning,
Reaction Motors Div., Thiokol Chemical Corp.*

WHICH IS more important: high specific impulse or lightweight hardware? We can answer this question, so crucial for space flight, if we know the "trade-offs" for the vehicle in question—the effects a change in one parameter will have on another, dependent parameter.

The most important parameters in space vehicle performance are payload and burnout speed. We can—by ballistic calculations—find out just how much either the payload or burnout speed can be increased (or decreased) by a certain change in either hardware weight or specific impulse (I_{sp}). Since payload and burnout speed are mutually dependent, one must be held constant, while the other varies as a function of propellant

*Reaction Motors Div., Thiokol Chemical Corp., Denville, N. J. The author wishes to acknowledge the help of W. T. Harrison, who established the calculation procedures, and of R. Barrow, who carried out the calculations together with Mr. Harrison.



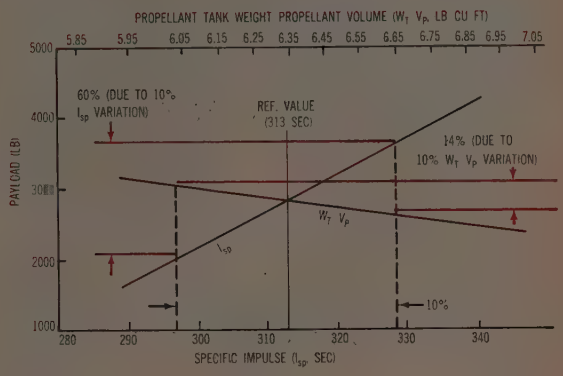


FIGURE 2: Effect of I_{sp} improvement (left) on escape vehicle booster with R=2.8, ΔV=5200 fps, T/W=85 and top, stage with R=6.4, ΔV=19,200 fps, T/W=100. Right: Effects of escape vehicle I_{sp} and hardware weight on top stage with R=2.8, ΔV=10,500 fps, T/W=100. A 10 per cent improvement will be four times as effective in I_{sp} as in hardware weight; the effect of a one-second increase in I_{sp} will equal that of a 50-lb. weight reduction.

and hardware changes. In our case, we will take burnout speed as the constant.

Curves or numerical relationships expressing the tradeoff among payload, I_{sp}, and hardware can be useful in several ways:

- They help in choosing design elements that have a predominant effect on only one major powerplant variable (I_{sp} or hardware weight) and also an important effect on cost or reliability. An example might be the choice of a new propellant.
- They answer our starting question about the relative importance of high specific I_{sp} impulse and hardware weight by showing whether a given increase in I_{sp} will produce a larger payload or a given reduction in hardware weight. In other words, they tell us how many pounds of hardware we can profitably add to get a given rise in I_{sp}.

A simplified version of the basic equation relating I_{sp} and hardware weight might be put as follows:

$$V_{bt} = I_{sp}g\ln (M_{PL} + M_{HW} + M_P)/(M_{PL} + M_{HW}) - gt_b\sin\theta,$$

where V_{bt} is theoretical (drag-free) burnout speed (in fps); I_{sp}, specific impulse (in seconds); M_{PL}, M_P, and M_{HW}, mass of payload, propellant, and hardware, respectively (all in lb-sec²/ft); t_b, engine burning time (in seconds); and θ, the angle between the trajectory and the surface of the tangent through the launch site. For our purposes, we can forget about the expression on the right involving t_b and focus on the I_{sp} term and the mass fraction $(M_{PL} + M_{HW} + M_P)/(M_{PL} + M_{HW})$.

Space missions require theoretical burnout speeds of at least 30,- 40,000 fps. To reach such speeds with available values of I_{sp} (250 seconds at sea level to 350 seconds in space), we must resort to staging.

For example, three stages may be needed. Then each stage must add a theoretical speed increment of some 10,-13,000 fps. The burnout speed equation shows the mass fraction must be about 2.5-3. The exact value depends on the required speed increment and the I_{sp} of the stage in question.

Generally, it is better to make the upper stages contribute larger speed increments than the lower ones,

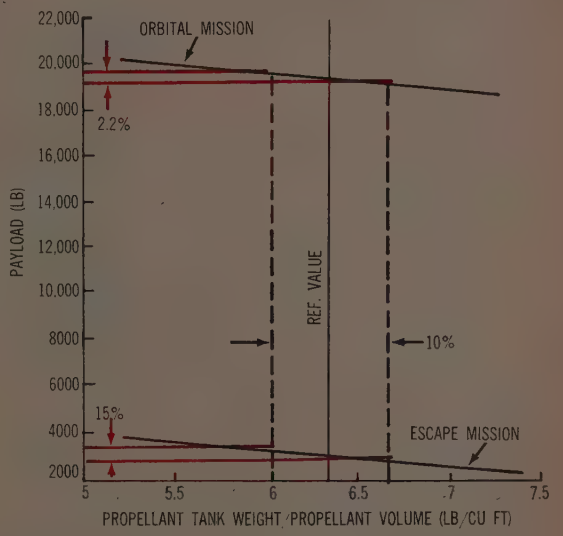


FIGURE 3: Effect of higher velocity requirement on importance of hardware weight, as shown by orbital top stage as defined in Figure 1 and escape top stage with same I_{sp} and R=6.4, ΔV=19,200, T/W=100.

more on next page

MOST successful U. S. rocket engines in spacecraft class to date are those of the Rocketdyne cluster that pushed an Atlas ICBM into orbit last December. Total thrust of the two boosters and the single sustainer reportedly is 335,000 lb in the regular missile installation. Weight of the orbiting Atlas was 8500-8700 lb.

since they are essentially unaffected by drag. The upper stage therefore usually will have a high mass fraction—around 3 for a three-stage orbital vehicle. To get such values, we must put a lot of propellant in the upper stages. This is done mainly by keeping the payload weight low.

Somewhat lower mass fractions are used in the lower stages—around 2.5 in the booster of a three-stage orbital vehicle. Such values are reached because the payload of the booster is the sum of the upper stage and the orbital payload. During its firing period, the booster expends a relatively small percentage of vehicle mass (as propellant) compared with the upper, high speed stages. This difference between the mass fractions of the upper and lower stages has a significant effect on the relative importance of hardware weight (*Fig. 1*).

In the top stage, for which a high mass fraction is obtained by using a large amount of propellant and the sum of hardware and payload is minimized, the propulsion hardware may weigh much more than the payload (possibly twice as much in the case of an escape vehicle). In such a situation, a reduction in hardware weight through design improvements is very important. (When the payload gets heavier, the significance of propulsion hardware diminishes.)

In the booster, the payload almost always is heavy, since it includes the upper stages. The hardware in the booster usually is quite light by comparison—five per cent of the payload weight is typical. The effect of an improvement in hardware weight will be slight.

Big factor is the mass fraction

We can see that, for chemical rockets, the relative importance of I_{sp} and propulsion hardware basically depends on the mass fraction, which in turn is controlled by the payload. This doesn't mean that I_{sp} is not important. It merely means I_{sp} isn't subject to as much adjustment as the mass fraction, which can be changed at will by adjustment of the payload.

The total velocity requirement and the number of stages also influence the mass fraction. In general, if we hold the number of stages constant and increase the burnout velocity, we must raise the mass fraction for each stage. To do this, the payload must be reduced. Hardware weight thus becomes more important in each stage, and especially in the final stage (*Fig. 3*).

If we hold the burnout speed constant and add stages, the speed contribution of each stage is reduced (through a reduction in the mass fraction). Hardware weight now is less important.

The numerical size of all the effects we have mentioned so far is affected by the starting point, or the state of the art in hardware design used as a reference point. Generally, if the hardware is highly refined to begin with, weight improvements will have a smaller effect than if it is unsophisticated (*Fig. 1*).

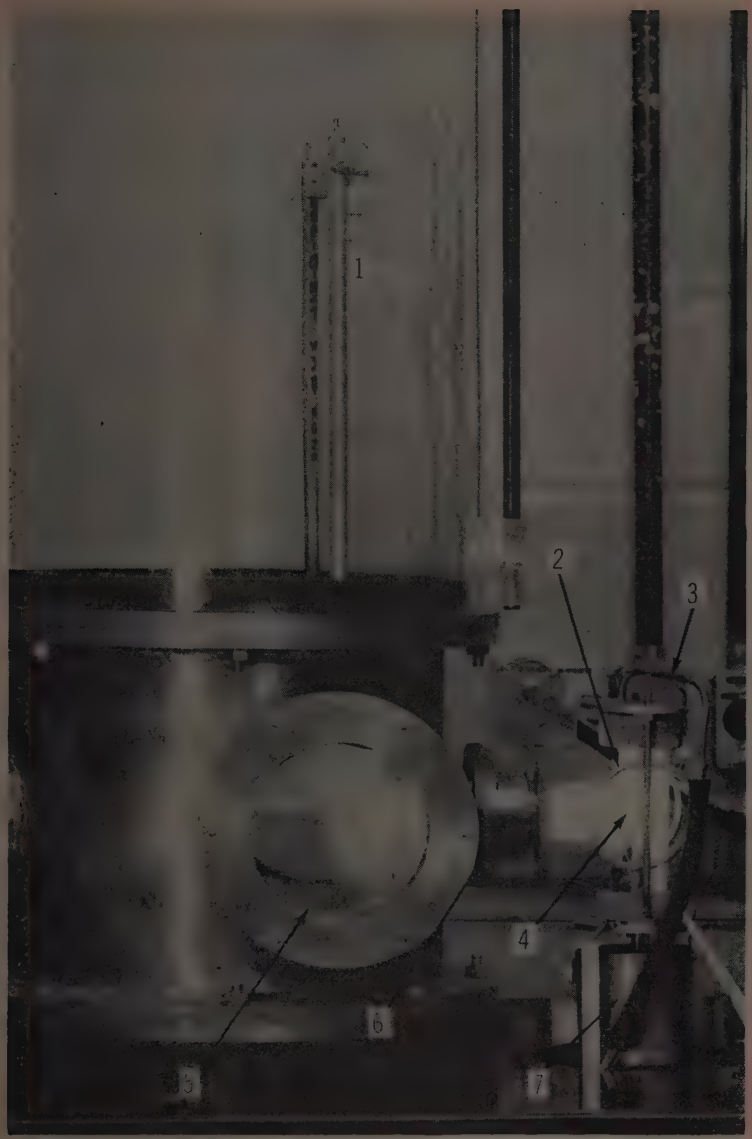
Now let's shift our attention to I_{sp}. Just like hardware weight, it is obviously more important in the top stage than in the booster because the top stage is part of the payload for the previous stages. Its importance is a function of the same factors that affect the hardware. However, the outstanding factor for the importance of I_{sp} is the stage speed requirement. High I_{sp} is more important in a stage that must produce a large speed increment than it is in a low speed increment stage.

In a multi-stage vehicle, we have seen, the upper stages are given more speed than the lower stages (to lessen drag). I_{sp} therefore usually is more important in the top stage on this score as well (*Fig. 2*).

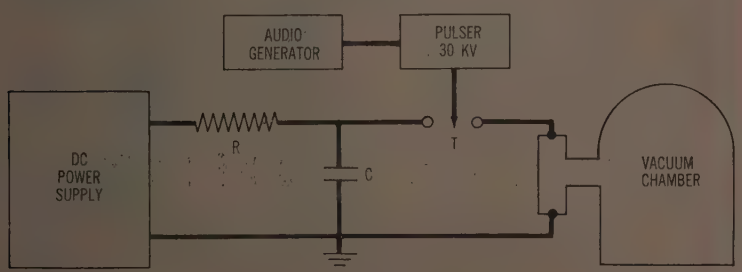
The obvious question now is, "Which is more important for the payload—top stage I_{sp} or top stage hardware?" To find the answer, we must look at a typical case. In *Figure 2*, the speed requirement is high, the reference hardware isn't very sophisticated, and the I_{sp} isn't the highest attainable.

We can see that a 10 per cent improvement in I_{sp} will be four times as effective as a 10 per cent improvement in hardware weight, and that the effect of an increase of one second in I_{sp} equals that of a 50-lb reduction in tank weight. In this example, I_{sp} clearly is more important than lightweight hardware.

The trade-off conditions shown in *Figure 2* certainly support the need for a strong R&D effort to get higher I_{sp} values. Of course, in another design, a 10 per cent improvement in hardware might be more effective than a corresponding improvement in I_{sp}—if the hardware were extremely poor to start with, the payload of the stage extremely small, and the stage speed requirement low.—End



PLASMA JET is exhausted into evacuated brass chamber with belljar, simulating space conditions. System's pressure is kept at 0.1-2.0 mm Hg. Thrust is measured with a plastic, disk-shaped pendulum placed in line of exhaust so angular deflection can be read on calibrated scale. Detail: (1) pendulum supports, (2) accelerating coil, (3) fuel inlet, (4) plasma gun, (5) scale, (6) high-vac connection, (7) switch. Below: Motor's circuit is simple charge-discharge network. Key elements are triggered capacitor energy switch (T) and plasma gun (load). Present circuit values: capacitance, 10 ufd; charging resistance, 1200 ohms; ringing frequency, 51 kc (0.96 uh inductance, 0.75 ohms resistance).



design progress

by Bernard Kovit
Associate Electronics Editor

Pulsed plasma accelerator forecasts spacecraft control

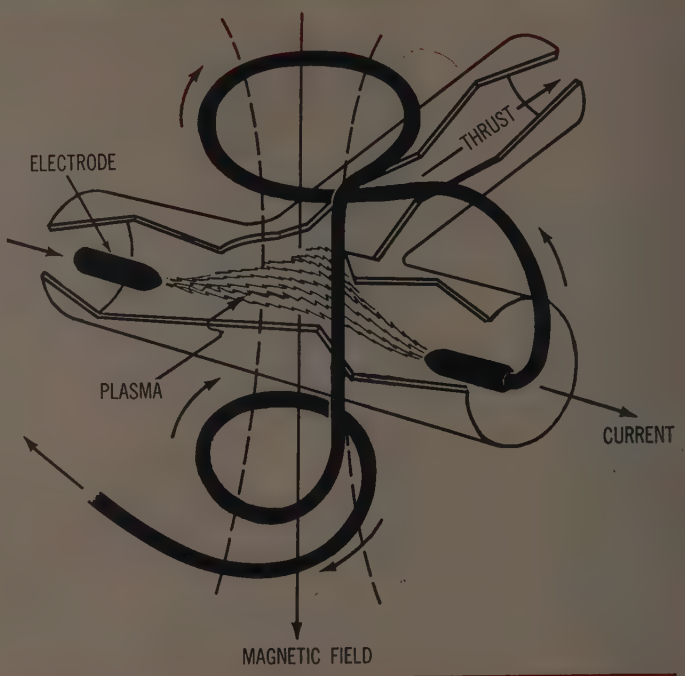
WORKING MODEL of a pulsed plasma accelerator was developed by Aerosciences Lab at General Electric Missile & Space Vehicle Dept. (MSVD), 3198 Chestnut St., Philadelphia 4, Pa., to demonstrate the feasibility of pulsed plasma propulsion for spacecraft attitude control. Basically the device produces high specific impulses by electromagnetically accelerating a low density gas. Motor is simply a high current spark circuit using the repelling magnetic field set up by its own current to elongate the spark. Though the lab model moves very small masses per spark (about 60 ug at a 20-pps repetition rate), the resulting high exhaust velocities of the gaseous fuel provide usable thrusts (of about 0.05 oz) depending on the audio frequency rep rates of the spark. A gas of lower weight, more efficient coupling of magnetic field to plasma, and lower power needs will eventually allow thrusts of a pound or more—enough for main power in outer space, says GE.

more on next page

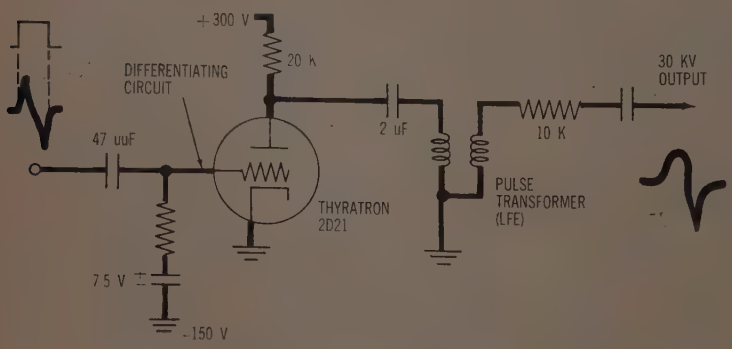
design progress

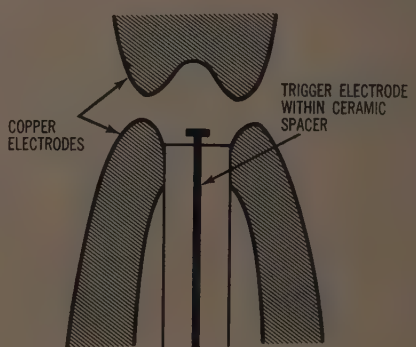
EARLIER GUN model used a brass strap (arrow) to set up propelling magnetic field. Present coil assembly gives more efficient field-plasma coupling at the low energies that are now used.

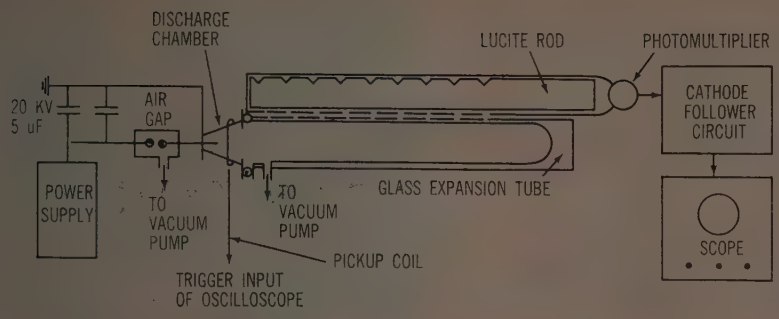
"GUN" MECHANISM is a pyrex T-tube, two arms of which mount brass electrodes that pass current through the enclosed gas. Third arm carries the exhaust. High gun currents that set up magnetic field are produced by rapid capacitor discharge when the switch is triggered. Currents are returned through single-turn copper coils on either side of the spark (or plasma), thus setting up a magnetic field normal to the plasma flow. Resulting Lorentz force (mutually perpendicular to the enclosed current and the magnetic field) depends on the square of the discharge current. With dc input of 4.5 kv, peak current and magnetic field are about 12,000 amp and 1750 gauss, respectively. At repetition rate of 20 per second, for instance, power input of three kw gives about 0.05 oz thrust. Higher repetition rates give higher thrusts. Gas velocity attained by the model is not precisely known; estimates based on single-shot discharge measurements peg it at about one cm/usec, or slightly over 22,000 mph. This would place the average mass moved per burst at about 60 ug, including vaporized electrode material.



PULSER CIRCUIT—Capacitor switch is triggered by 30-kv pulse transformer whose primary winding is in plate circuit of 2D21 thyratron fired by differentiated square wave from audio signal generator. While protecting against supply overload, capacitor charging time constant (CTC) must still occur within cycling period. With charging resistance fixed, capacitor voltage must decrease with cycling frequency. Output thrust increases with voltage and cycling frequency, in latter case over a range limited by CTC. Capacitor switch (below) is a spark gap broken down by means of trigger electrode. Switch electrodes are hollowed to cut trigger wear.

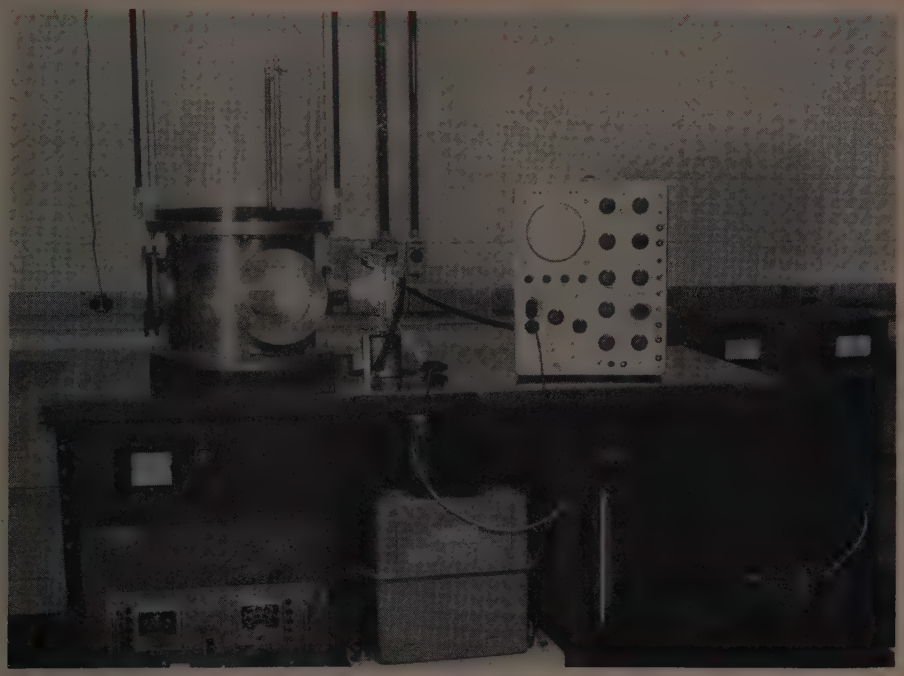






VELOCITY MEASUREMENT—Single-shot gas velocities are measured as function of input energy, ambient pressures, and distance. Bright exhaust is directed into pyrex tube (75 cm long, 46 mm ID). Outer opaque tube has nine equidistant 7.5-cm slits. Light falling on adjacent Lucite rod from slits forms pulse that travels along rod to photomultiplier. Trigger pulse for this method comes from single turn of wire at discharge.

FEASIBILITY EXPERIMENT — Major components are gun, five-kv dc power supply, charging resistor network, switch capacitors. Their total weight is about 700 lb, of which about 70 per cent is power supply. Overall stored-energy conversion efficiency is only about 3-7 per cent, but efforts to cut power loss in plasma expansion tube and switch will improve it, says GE.



TYPICAL PERFORMANCE DATA*

Capacitor energy (joules)	Ambient pressure (mm Hg)	Exhaust velocity (fps)	Specific impulse (sec)	Impulse (lb-sec)	Thrust (oz)
50	0.2	15,400	480	0.11×10^{-3}	0.03
	0.7	8,200	250	0.22×10^{-3}	0.07
100	0.2	23,900	750	0.15×10^{-3}	0.06
	0.7	13,100	410	0.33×10^{-3}	0.10
250	0.2	37,400	1170	0.32×10^{-3}	0.10
	0.7	20,300	640	0.45×10^{-3}	0.14
500	0.2	57,400	1800	0.79×10^{-3}	0.25
	0.7	29,500	920	1.2×10^{-3}	0.35

*For single-shot operation using air as fuel at same initial pressure in chamber and gun. Repetition rate is 20 pps (measured at 18 cm from discharge).

FUTURE DEVELOPMENTS

GE is studying conical- and T-tube discharge and electrodeless gun configurations. Great promise is seen for combining one of these with transmission-line techniques to prolong plasma acceleration and up exhaust velocity. Higher exhausts and shorter tubes will increase power conversion efficiency. Optimum fuel injection and need to simulate space conditions dictate next step—operating the entire system under high vacuum and finding out how to inject pulses of gas to coincide with the electric firing rate. Helium and other low-molecular-weight fuels are being tried. Meanwhile, says GE, accurate method of measuring "microthrusts" is still being sought.

Storable and Powerful Rocket Fuel Oxidizer

CTF

Chlorine Trifluoride (ClF_3)

Much is expected of Chlorine Trifluoride as a rocket fuel oxidizer. That's because it combines good handling and storage properties with very high performance. To be specific:

CTF is not difficult to handle! Boiling point of Chlorine Trifluoride is 53.15°F. Freezing point is −105.4°F. Vapor pressure at 140°F is 80 psia.

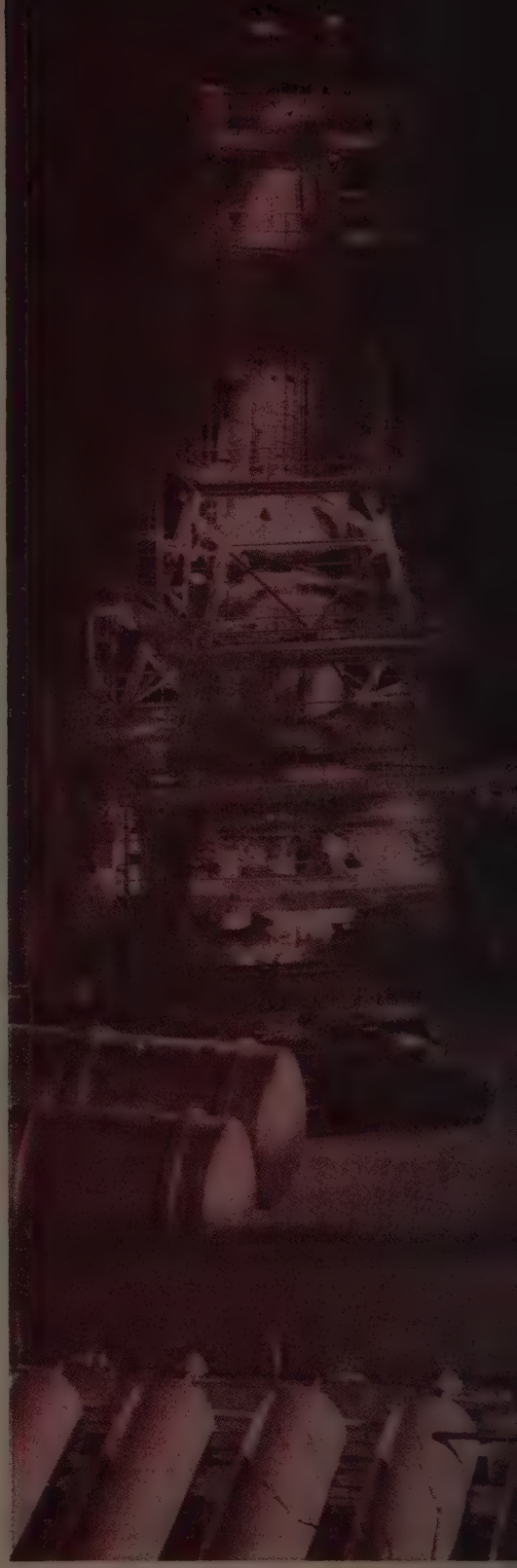
CTF may be stored conveniently! Chlorine Trifluoride is storable over a very wide range of temperatures. You can count on years of storage life!

CTF has excellent stability! Shock resistance of pure CTF is very high. And it is thermally stable to high temperatures.

CTF offers high performance! The high density of Chlorine Trifluoride (1.825 at 68°F) leads to outstanding density impulse values. An important plus—CTF is hypergolic with hydrogenic fuels over a wide range of pressures and temperatures.

Fluorine and other Fluorine-Based Oxidizers

CTF is one of several fluorine-based chemicals produced by General Chemical which are now considered as excellent rocket-fuel oxidizers for various missions. Another is Bromine Pentafluoride which shares many of CTF's desirable physical and chemical properties. General Chemical, the sole producer of elemental liquid fluorine, has extensive technical data available on Fluorine and Halogen Fluorides. Write today for further information on these high-energy oxidizers.



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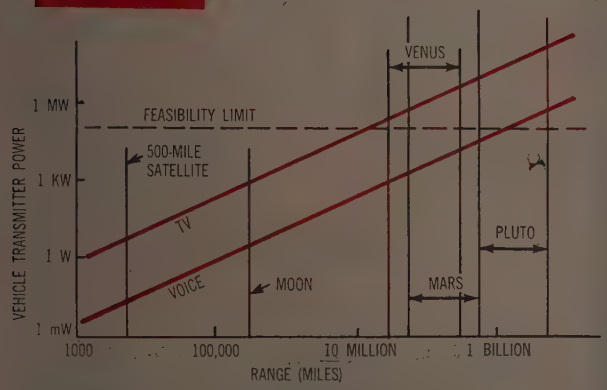

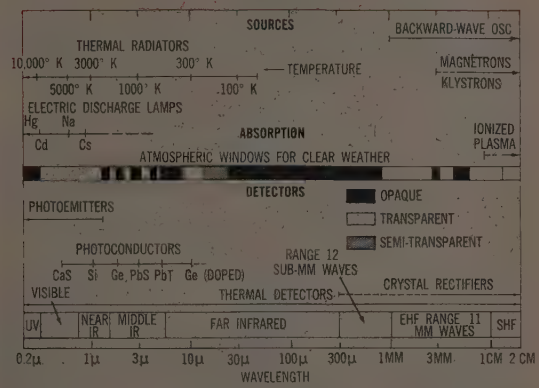

POWER NEEDS for space communications (left), as seen by Roy K. Knutson, chairman of NAA's space committee. (High gain antennas are assumed.) Right: Centimeter, millimeter, and micrometer frequencies will find wider use in space electronics, spurring on the development of sources and detectors for these regions.

State of the art: Electronics

- **"Milli-micro-subminiature" components will be needed**
- **Nuclear batteries to meet power requirements**
- **Antenna stabilization an urgent problem**

WHAT WILL the electronic circuits, systems, and components look like that will guide, control, propel, compute, and communicate for future space vehicles? Obviously, they will be derived from today's technology. But beyond that, we really don't know.

As GE vice president Dr. George Haller puts it, "every experiment in space produces results which had not been anticipated. . . ." A lot more basic research is needed before even the parameters are set for future space electronic engineers to design to. From what we do know it appears that the prime factors that will set space electronics apart are the fantastic magnitudes involved—in range, precision, operating time, and reliability.

Just to hit the moon, for example, would tax the most advanced of today's guidance systems. A lunar impact vehicle traveling at 35,100 fps (a reasonable speed for such a vehicle that has initial uncorrected errors of 0.6 per cent in velocity and one degree in azimuth would miss its 2160-mile-diameter target by some 12,000 miles. The trip would take some 60 hrs.

A similar mission to Mars would take around 200 days. The navigation computer for calculating the trajectory between earth and Mars orbits would have to be accurate to one part in a million—which requires a word length of 20 binary bits. To limit the failure probability, mean time to failure of just the computer's electronic components would have to be nearly 1000 years.

Beefing up performance and reliability by successive extensions of present designs might help meet the spects for our first faltering steps into space. But the magnitude of the quantitative demands is bound to force marked qualitative design changes.

The extremely large payload-takeoff-weight ratios of space vehicles (something like 1:1800 for an unmanned lunar probe) call for equipment that is "milli-micro-subminiature" and uses as little power as possible. Should we get a breakthrough in propellants or propulsion schemes, the ratio could be drastically cut. Still it's a safe bet that equipment weight and size will be restricted more sharply in spacecraft than in aircraft and missiles for a long time to come.

Molecular electronics—which is still in its infancy—conceivably could furnish the answer to space vehicle equipment miniaturization. Components as we know

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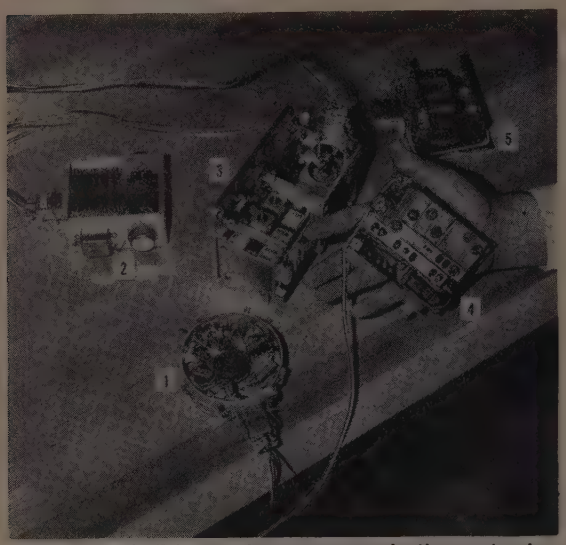
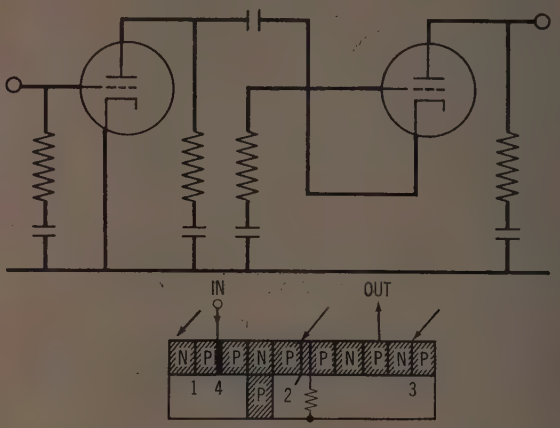
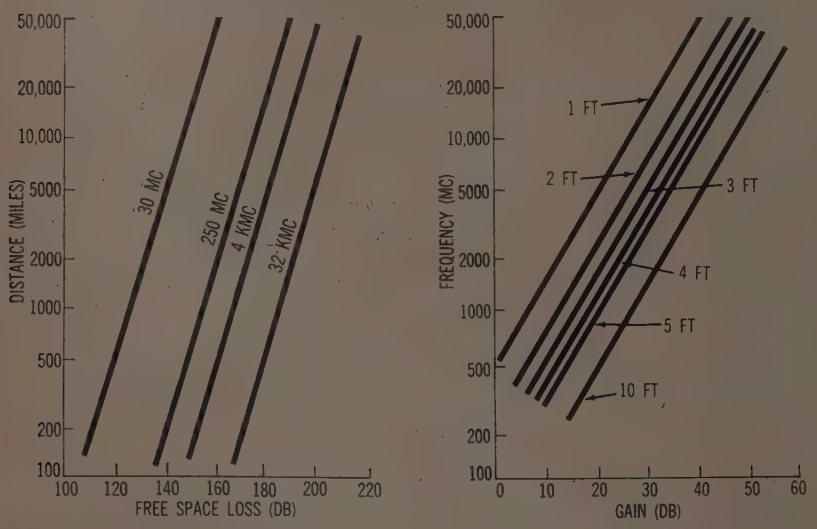


PROJECT SCORE'S spaceborne communications relay included (1) ¾-lb beacon transmitter, (2) power converter for operating transmitter, (3) 2½-lb, eight-watt transmitter, (4) 10-oz transistorized receiver, (5) ¾-lb receiver control. Built by RCA's Astro-Electronic Div., these units are not very different from those in high performance planes and missiles. Future spacecraft probably will use much smaller units (mostly of solid-state, "molecular" design).



CONVENTIONAL AMPLIFIER (top) and its future as solid-state equivalent suggested by C. L. Brunetti—a sequence of rate-grown PN junctions. Energy enters Brunetti's device by shining light on junctions 1, 2, and 3. Certain junctions act as resistors, being biased in direction of high resistivity. Junctions 2 and 4 are emitter junctions for circuit's two transistor combinations. With incident light as power source, Brunetti points out, number of connections is reduced, blocking capacitors are eliminated, device's minimum dimensions are set by diffusion lengths of carriers in the respective junctions. Circuits like this one offer exciting possibilities for space systems.



COMMUNICATIONS WITHIN SPACE will probably use frequencies from VHF to around 32 kmc. Higher frequencies suffer more from attenuation (top) but get more gain for given dish size (bottom). Compensating effects therefore allow broad frequency choice. Loss (in decibels) equals 10 log $(4543F^2D^2)$, where F is frequency (in megacycles) and D is distance (in miles); gain (in decibels) equals 20 log F+20 log D—52.6, where D is dish diameter (in feet).

them today wouldn't exist any longer. In their place would be thin films of material, producing the desired effect through their combined electric and/or magnetic properties.

One of the most important questions about electronics in space is, Where will the electric power come from? The power needs of present satellites range from a fraction of a watt to a few watts. The talking Atlas satellite was an exception—it needed some 30 W, yet its voice communications (the largest power drain) lasted only 13 days. Future vehicles—especially if manned—will need from hundreds of watts to tens of kilowatts. If electric propulsion is used, we might need megawatts (though for short periods only).

Chemical batteries (silver-zinc, nickel-cadmium, and the fuel cells) suffer from the fact that their mass is directly related to their energy content. Today, the W-hr value per pound of battery weight is 15 for the

nickel-cad type, 40 for the silver-zinc type, and 300 for a hydrogen-oxygen fuel cell. For a long trip—even when only a few watts are needed—battery size would be exorbitant.

Though its conversion efficiency is only 4-10 per cent, the solar cell has the advantage of drawing its energy from an unlimited source. The life of silicon solar cells is estimated at 2000 years. On Vanguard, such cells periodically re-charge nickel-cadmium batteries and so have kept the satellite's 40-mw transmitter broadcasting since March 17, 1958.

However, solar cells need about 10-25 sq ft of area in direct view of the sun to supply 100 W. Because of this, they may have a practical limit of light to moderate loads (and, because of the inverse-square law, to the "near" region of the solar system out to the Martian orbit).

Nuclear batteries look best now

Of the known electric sources, nuclear batteries really look like the best bet. They consist of a radioactive element and an energy converter. The latter determines the efficiency and so—to a large extent—the practical power levels.

So far thermocouple, thermionic, photoelectric, electro-static, and electron-voltaic methods of conversion are being used. The first two are most efficient (10-20 per cent) and the only ones practical for high power (hundreds of watts). Both convert the heat created by nuclear radiations into electricity.

Snap, being developed by Martin for USAF, is a thermocouple nuclear battery. It uses polonium, a radioisotope that emits alpha particles and very few gammas. Polonium has a half-life of 138 days; during this time the battery provides some 2000 W-hr/lb.

Cerium, a radioisotope with twice the half-life of polonium, is being considered for future use. However, it is a beta emitter with strong gammas and would require heavy shielding.

A thermionic nuclear battery that uses gold as its source (but could also use cerium) has been developed by GE. Weighing less than 25 lb, such a battery could supply energy at a 100-W rate for a year in space environments, claims GE. A multi-hundred watt conversion unit could be available in 1-2 years, the company says.

For higher kilowatt and the megawatt ranges, small reactors could be substituted for the radioactive element in the "thermo" batteries.

Probably the first practical use of electronics in space will be earth-to-earth satellite communications relays. These will finally enable man to overcome the earth-curvature barrier. The feasibility of a communications satellite has already been demonstrated by Atlas. Almost innumerable schemes have been proposed, which would use passive and active relays, orbiting and "stationary" satellites, voice, teletype, and other forms of data transmission.

As the range of space vehicles increases so will the communications problem. Earth-to-"deep"-space and space-to-space communications will call for new designs to overcome the propagation barrier created by the vastness of space.

One of the first big posers facing the communications designer will be antenna stabilization. Because of the attenuation over large ranges, antenna gain is needed. For gain you need directivity, and directivity presupposes stabilized antennas. Long range communications in space may eventually resolve into a problem of how well both transmitting and receiving antennas can be aimed.

An isotropic antenna, which radiates omnidirectionally over a sphere, would require too much power. (The amount of energy intercepted by a receiving antenna is proportional to $A/4\pi r^2$, where A is the area of the receiving antenna and r is the range between the two—transmitting and receiving—antennas. For acceptable communications between an earth satellite and Mars, something like a billion watts of average power would have to be radiated from an isotropic source.)

What is urgently needed for space vehicles is antennas with the contradictory properties of small size, high gain and omnidirectivity. This will call for breakthroughs in the art (if it's possible at all).

There will, however, be a practical limit on beam sharpness. Since a receiving antenna—either in space or on earth—is going to have to intercept the transmitted signal, the beam can't be so narrow that unduly complex tracking mechanisms are needed at the receiving end.

Stabilization will be a compromise, too. Over short and medium ranges, a more powerful transmitter and an omnidirectional antenna might actually take less weight than a weaker transmitter and a directive antenna.

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Proposed Frequencies for Space and Earth-Space Services[1]

Allocation	Frequency (mc)
Earth-Space	25.6 — 25.65
Under study for allocation for space and earth-space services	100—150[2]
Earth-Space[3] Fixed Mobile Space[3]	1700—1725
	1825—1850
	2275—2300
	8300—8400
	15,150—15,250
	31,500—31,800

(1) Proposed by Federal Communications to International Telecommunication Union for communications and radio command use.

(2) Frequencies in this band would be chosen from those now allocated exclusively to government services.

(3) Proposed for allocation on world wide basis.

367 SYSTEM COMPONENTS

Compressors — Will deliver from 0.5 to 10 SCFM at pressures up to 3000 psi, through a full range of altitudes and temperatures. Choice of hydraulic, AC, DC or engine drive. Smallest, lightest and coolest running of any made.

Pressure Switches — Both low and high pressure. Gage or absolute type. Pneumatic or hydraulic. Normally open or closed. Full range of differentials.

Pressure Regulators — Precise regulation from 2 to 2000 psi, with inlet pressures up to 3000 psi and capacities up to 150 SCFM. Both absolute and gauge types available.

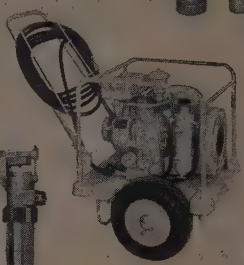
Compressor Packages — Complete pneumatic systems based on Cornelius compressors, include inlet air filter, starting relay, radio noise filter, moisture separator with automatic condensate dump and heating element, back pressure valve, check valve, relief valve and pressure switch.

Pressure Relief Valves — Compactness with accurate settings from .5 psi to 4000 psi. Vacuum and combination pressure-vacuum models also available.

Pressurization Pumps — Weight 4 lbs. with explosion-proof AC or DC motors. For pressurizing de-icer and water systems, electronic equipment, hydraulic and fuel reservoirs. Rated at 1 CFM of free air at 25 psig and altitudes up to 50,000 ft. Available as complete system with check valve, relief valve, pressure switch, and dehydrator.

Chemical Driers — 3000 psi service. Long life desiccants. Capable of operating up to 275° F. Rated for dew points down to —65° F.

Air Storage Bottles — Lightweight aluminum construction, rated up to 2000 psi, these reservoirs meet MIL-C-7905A with weights as low as 2 lbs.

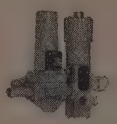


Emergency Air Brake Valves — Metering type designed for sensitive hand or foot operation with inlet pressures up to 3000 psi and brake pressures up to 2000 psi.

Portable Compressors — Complete, compact, ground support systems. Weigh less than 100 lbs. Pressures up to 4000 psi. Air delivery up to 5 SCFM. Ideal for missile, aircraft or "retriever" service. Industrial versions for OM, shop and lab use.

Moisture Separator Assemblies — Complete 3000 psi system assemblies consisting of integral pressure switch, relief valve, check valve, automatic solenoid operated dump valve and thermostatically controlled heating element.

Hydraulic Motors — Long life, rugged, 3000 psi motors for Type II systems. Features completely new Cornelius design.



Anti-G-Valves — Government standard equipment, meets AN-6538 specification.

AC and DC Motors — Explosion-proof, light weight, continuous duty. For operation within full range of altitudes and temperatures.

Hydraulic Pumps — exclusive Cornelius design for 3,000 psi Type II systems. Both variable and fixed displacement.

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Guidance Accuracy for Lunar Impact[1]

Thrust Correction		Required Guidance Accuracy		
Correction Made at	Magnitude of Velocity Change To Correct for Initial Errors (fps)	Requirement Applies at	Tolerable Velocity Error (fps)	Tolerable Azimuth Error (deg)
cutoff	none	cutoff	78	0.58
crossover[2]	2500	cutoff	210	2
		crossover	520	12.1
midcourse (75,000 mi)	460	cutoff	210	2
		midcourse	87	0.9

(1) Assumed initial guidance error one degree in azimuth, 105 fps in velocity; vehicle travels at 35,100 fps nominal velocity. Midcourse and crossover are computed from the center of the earth, from which the problem starts. From C. A. Brown & R. Fleisig (Astronautics Section, Air Armament Div., Sperry Gyroscope), 'Simplified Space Guidance System Analysis;" 5th Annual Meeting, Amer. Astronautical Soc., '58.

(2) A point at which the earth's and the moon's gravitational field are equal. It is assumed a change-over from earth to moon navigational coordinates is made at crossover.

The operating frequency for space communications will be dictated by a number of considerations. Cosmic noise (about six decibels at 100 mc, decreasing at roughly $1/f^{2.3}$) sets the lower limit for today's receivers at about 150 mc. Parametric and maser low noise front ends extend the cosmic threshold to 1000 mc. On the other hand, attenuation limits waves passing through the atmosphere to a practical high limit between 2000 and 3000 mc.

Another factor to be considered for tracking is atmospheric refraction and reflection. The refraction angle is proportional to $1/f^2$. For the one or two milliradians of accuracy that will be demanded, frequencies over 300 mc will have to be used.

Doppler shift will have to be considered, too—especially in narrow band systems. At escape velocity (6.83 mps), the Doppler effect could shift a signal as much as 350 kc.

Because of the combination of these factors, the 100-400-mc area might prove best for earth-to-space use. For space-to-space, the communications experts see a broad usable region from 30 mc to 30 kmc, with the exact frequency depending on the mission and the available components. Many designers also look to the development of the almost unexplored portion of the spectrum extending from the millimeter region up to—and even past—the X-ray bands for both communications and navigation.

Whether space communications systems will be radically different from today's systems, only the future will tell, but certainly they should be much more efficient. Undoubtedly, designers will put into hardware the best ideas gained from information theory on the optimum relations among such parameters as transmitter bandwidth, message bandwidth, signal-to-noise ratio, receiver noise figure, etc.

Statistical techniques will most likely govern the choice of modulation and demodulation schemes. Correlation detection, very stable oscillators for transmitters and receivers, and very narrow bandwidths should be in style.

Navigation and guidance to us today appear to pose a much more complex electronics problem in space than over the earth. Some of the obvious reasons for this are:

- extremely long flight times;
- too many unknowns (e.g., we have no accurate knowledge of the distances, masses, and gravity, radiation, and magnetic fields in our solar system);
- trajectories and travel times must be held precisely, since slight divergencies can result in tremendous errors;
- the unpowered "free fall", or zero-gravity phase of flight is completely novel to the human navigator, who is used to constant-thrust vehicles that constantly close out the off-course error;
- for inertial guidance systems, there is no "g" in space—the accelerometers will always read zero in "free fall", allowing no reference (as on earth) for the accelerometer; nor is there Schuler tuning available to close out errors—gyro errors could increase as the cube of time.

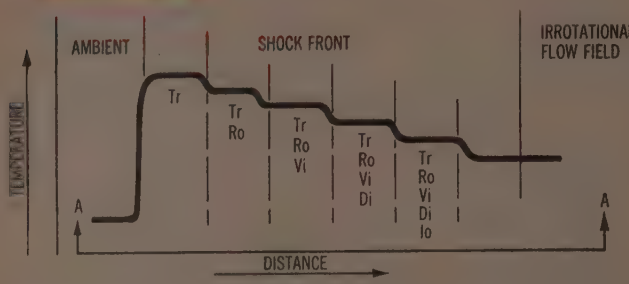
"ICBM-type" guidance for moon shot

For a coarse moon shot, uncorrected "ICBM-type" guidance could be used. For "fine" lunar navigation as well as for trips to Mars, Venus, and beyond, midcourse corrections and a terminal guidance aid would be needed.

The space navigation problem can be divided into three phases: (1) ascent into orbit, (2) "free fall", and (3) re-entry and descent. The guidance for the first phase will probably be fairly similar to that used in an ICBM—pure inertial, command radio, or a combination of the two.

For the "free fall" phase, optical devices, infrared, and radar look most probable for position determination. Inertial guidance (periodically corrected by optics, radar, or the like) could be used to monitor corrective thrusts to get back on course. It can contribute nothing during the unpowered phase of flight, since it supplies no new information.

For re-entry and descent, radio, radar (including Doppler), inertial devices, or combinations of these could supply the necessary guidance data.—End



TRANSFORMATION OF ENERGY (left) across a shock front as the air molecules successively undergo translation (Tr), rotation (Ro), vibration (Vi), dissociation (Di), and ionization (Io) during re-entry atmosphere. Right: Typical plot of plasma resonant frequency as function of the distance from a flat surface.

Shock ionization changes EM propagation characteristics

Whenever a spacecraft leaves or enters a planet's atmosphere, the progation characteristics of its electronic equipment change sharply—for the simple reason that the craft creates enough of a disturbance in the molecules surrounding it to change their dielectric constants and conductivities. Fortunately, these effects of "shock ionization" can be fairly well estimated in advance.

by W. Sisco and J. M. Fiskin, Staff Propagation Research Scientist & Propagation Research Scientist, Douglas Aircraft Co., Inc.,[1]

SPACE vehicles moving at hypersonic speed into or out of a planetary atmosphere surround themselves with a shock-induced sheath of ionized gases. Even in the realm of free molecular flow, where no shock waves are formed, the electron density of the gases surrounding the vehicle increases.

One of the immediate effects of this energized layer of gases is a change in the propagation characteristics of electromagnetic waves. Antenna impedances, radar cross-sections, voltage breakdown properties, and receiver noise levels also are modified.

Fortunately, in most cases these effects can be determined in advance or at least fairly well estimated for the equilibrium condition—provided the number density distribution of electrons and heavier particles behind the shock is known.

The first step in making numerical calculations of this distribution is to postulate the chemical reactions taking place and then set up equilibrium and conservation equations to find the constituents and concentrations of the hot, shocked air. The simultaneous solution of this set of concentration and conservation equation yields the required densities. Aerothermodynamics, statistical quantum mechanics, and experimental spectroscopy are all involved in the computations and analysis.[2]

Once the electron and heavier particle density distributions are known, the propagating and reflecting characteristics of the medium can be determined from classical electromagnetic theory. With dielectric constant and conductivity known, attenuation, phase shift, and reflection properties can be described.

For a plasma, the dielectric constant equals (using mks units):

$$\epsilon = \epsilon_o[1 - \omega_{cr}^2/(\nu^2 + \omega^2)]$$

and the conductivity:

$$\sigma = \epsilon_o\omega_{cr}^2\nu/(\nu^2 + \omega^2),$$

where ϵ_o is the free-space dielectric constant; ω, the incident radiation frequency (in radians); ν, the elec-

more on page 68

(1) Douglas Aircraft Co., Inc., Long Beach, Calif.

(2) C. A. Roberts, W. B. Sisco & J. M. Fiskin, "Theory of Equilibrium Electron and Particle Densities behind Normal and Oblique Shock Waves in Air;" Engrg. Rep. LB-25872, Douglas Aircraft, Long Beach, Calif. G. S. Rusbrooke, "Statistical Mechanics;" Oxford, '49.

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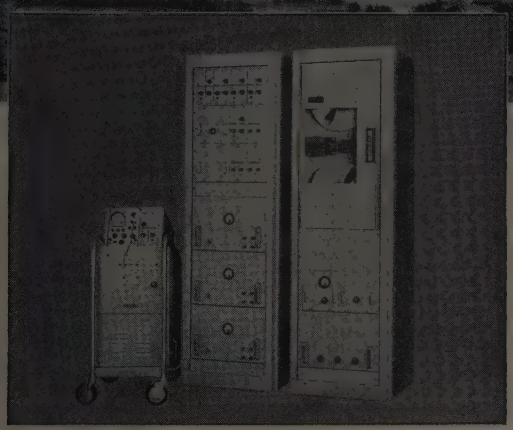

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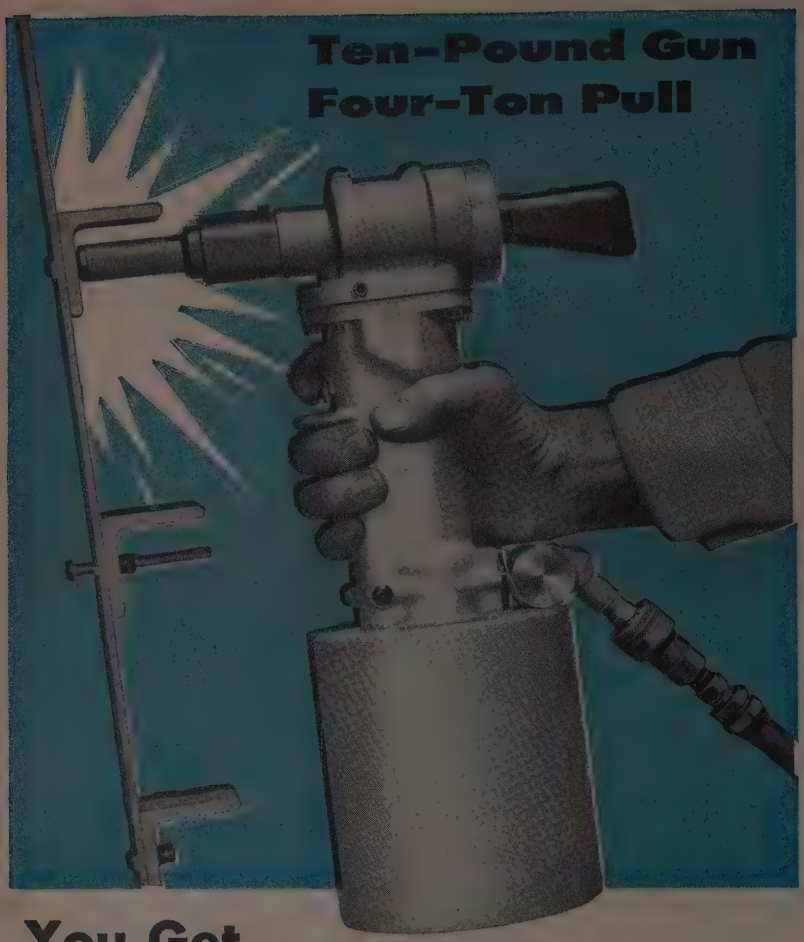

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For information on the new Cherry G-85 gun write Townsend Company, Cherry Rivet Division, Post Office Box 2157-P, Santa Ana, California.

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tron collision frequency; and ω_{cr}, the critical frequency (in radians).

The collision frequency is roughly the average number of times an average electron collides elastically with a heavier particle. For a mixed gas such as air, an approximate expression for ν is given by:

$$\nu = \bar{c}\Sigma_j n_j s_j,$$

where n_j is the number of species j per cubic meter and S_j the electron collision cross-section of the species (in square meters). The cross-section is generally a function of temperature and its value usually is found experimentally.

The constant c is given by:

$$\bar{c} = (8kT/\pi m_e)^{\frac{1}{2}},$$

where k is Boltzmann's constant (in mks units); T, the temperature of the medium (in degrees K); and m_e, the electron mass (in kg).

The critical frequency is given by:

$$\omega_{cr} = (Nq^2/\epsilon_o m_e)^{\frac{1}{2}},$$

where N is the number of electrons per cubic meter and q the electron charge (in coulombs).

In a shock-induced sheath, the radiation resistance of antennas attached to the surface of a hypersonic vehicle can differ appreciably from the free space value. Provided the shape of the ionized sheath is well defined, the impedance changes can be approximated by electromagnetic theory and the variations compensated for so that there is no loss in efficiency.

Radar cross-sections change because the shock-ionized layer in effect is an extension of the vehicle. As such it partially (and, sometimes completely) reflects incident radiation.

An ionized wake may also be created if recombination times are long. This changes the vehicle's radar cross-section for some frequencies. Again, this variation can be approximated if the shape of the sheath and wake are known.

Air in ionized sheath is quite different

Air in the ionized sheath is fundamentally different from the ambient air. Just how different it is depends on the temperature, which quantitatively determines dissociation, ionization, and formation of new products.

The air in the sheath has its own voltage breakdown properties. Theoretically it should be possible to calculate these properties since the composition of the air is known.

more on page 70

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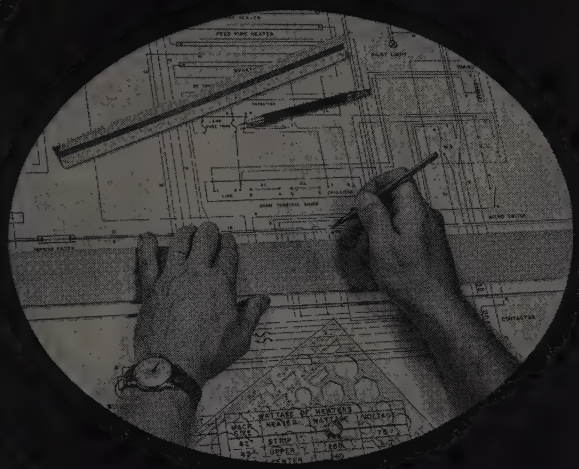

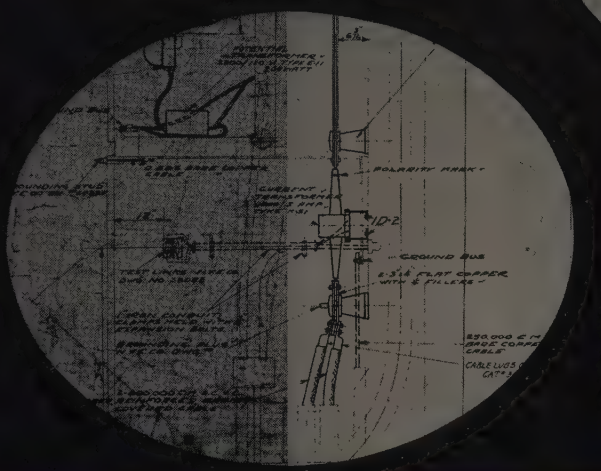

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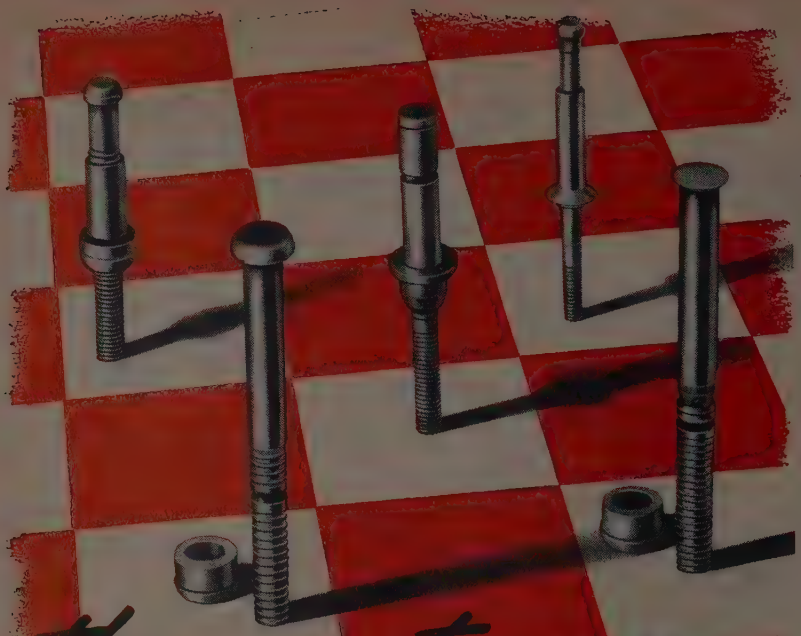

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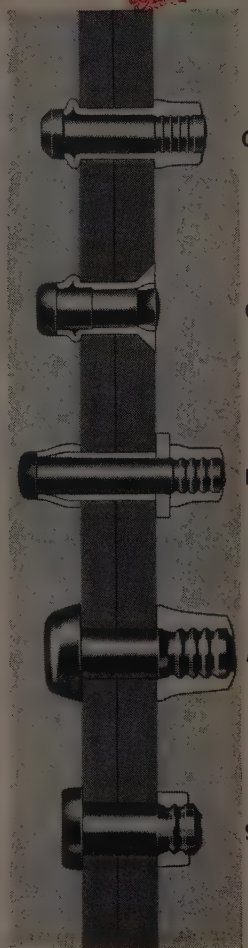

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Practically, however, this calculation is troublesome enough to make experimental determinations preferable—"holding" the air at the desired temperature and density and then actually measuring the rates of ionization and excitation due to the impressed electromagnetic field.

Impedance is also affected by hypersonic speeds. All vehicular antennas are surrounded by a conductive medium at high temperatures. The real impedance (as against the radiation impedance) appearing across the antenna terminals depends on the geometry of the antenna feed points, the shape of the shock wave sheath, and the conductivity and dielectric constant of the plasma.

The resistive part of this impedance—which can be considered in parallel with the modified radiation resistance—will generate an open circuit noise voltage over a wide frequency spectrum. If there are no relatively strong electromagnetic fields present within the medium, the noise power will be proportional to the electron temperature, i.e., the temperature of the shocked air.

EM fields raise effective electron temperature

Strong electromagnetic fields — such as are produced by high-powered radars — yield effective electron temperatures significantly above the thermal values. This results in even larger noise power outputs.[3] Generally, receiver system noise can be appreciably increased by the hot gases surrounding the vehicle.

Radiation from an ionized sheath may be very roughly classified as classical and quantal. Electron accelerations and decelerations within the gas generates antenna-type radiation. Rotation, vibration, electron excitation, and recombination of electrons with positive ions produces quantal radiation in the microwave, millimeter, infrared, visible, and ultraviolet ranges.

The magnitude and frequency of the radiation emitted into space depend on temperature, density, absorptivity, and size of the plasma. Enough radiation may be emitted to enable us to spot and track space vehicles in planetary atmospheres by means of passive detection systems.—End

(3)Sisco & Fiskin, "Effect of Relatively Strong Fields on Propagation of EM Waves through a Hypersonically Produced Plasma," Engrg. Rep. LB-25642, Douglas, Long Beach, Calif.

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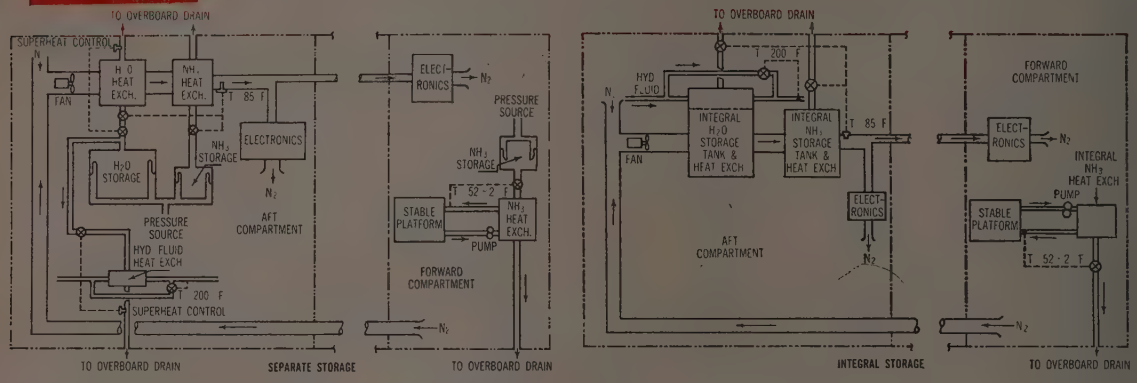

FIGURE 1: Separate- and integral-storage cooling systems proposed by Hamilton Standard for Dyna-Soar-type vehicles. Integral-storage system is said to be more reliable, but involves greater space and weight penalties.

State of the art: **Accessories**

- **X-15 designs point the way**
- **APUs are most critical items**
- **Component integration for manned capsules**

IT IS still too early in the development of space flight for definite design trends in accessory systems. However, we are far enough along —in prototype hardware, system analyses, and development studies —for a review of the first actual design applications.

The transition from aircraft to spacecraft use of accessory systems starts with the North American X-15, goes on to the Dyna-Soar, satellites and space probes, and ends (for the time being) with manned space capsules. On the X-15, details have been released on the pressurization and cooling system, the attitude control system, and the auxiliary power supply.

Liquid nitrogen, stored at about —300 deg F, is used as the main cooling and pressurizing medium. The nitrogen is distributed to various subsystem areas in liquid, gaseous, and spray form. It is circulated as a liquid through the pilot's space suit to cool and pressurize his body.

Probably the most remarkable use of the nitrogen is the spray that cools the nose cone and keeps it from "eroding." The nitrogen system also cools and pressurizes the electronic compartments.

One of the problems AiResearch had in developing this cryogenic system for the X-15 was to insure an uninterrupted flow of nitrogen under weightlessness and negative G conditions. The company's engineers decided to install a helium-filled, expandable plastic bladder in one end of the nitrogen storage container to force out the nitrogen.

Helium is also used to pressurize the X-15's hydraulic and pneumatic systems. Initially, the helium is stored at 3600 psi and —125 deg F. During flight, the heat rise in the vehicle builds up the pressure to 4400 psi.

The X-15 uses both conventional aerodynamic controls and hydrogen peroxide reaction jets. The latter are installed in the nose (for pitch and yaw) and in the wing tips (for roll).

more on page 74

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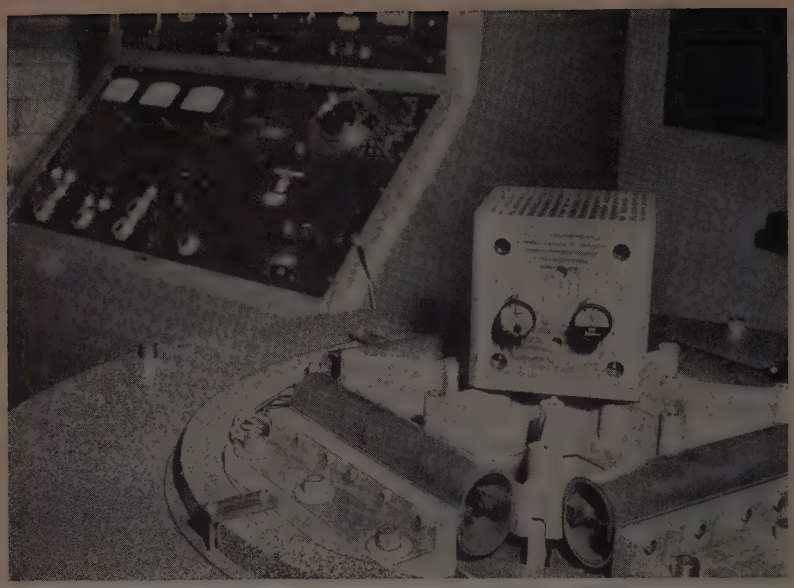

RMC-LINDSAY ONLY GAUGE TO STAND THIS TEST — This photograph shows vibration testing of RMC-Lindsay pressure gauges on the 3200 force pounds Calidyne Vibrator to 50 G output, amplitude .010 to .20. Cycling frequencies to 2,000 cps. The test is conducted so as to parallel actual installation conditions, with gauges subjected to 350°F under operating pressures. Complete test reports are available on request.

THE RMC-LINDSAY GAUGE IS RADICALLY DIFFERENT

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2. The pointer is attached directly to the end of the coil, with no linkages or pivots to be affected by vibration.
3. Superior techniques in coiling, heat treatment, calibration, and material specification are *new* and *exclusive* with RMC.
4. No other gauge can match RMC-Lindsay specifications:

PRESSURE RANGE: Pressures in ranges 0 to 1,000 p.s.i. up to 15,000 p.s.i. with retard scales available. OVERLOAD PRESSURE: Nominal overload pressure factor of 2.0 times the maximum dial reading (higher factors available). BURST PRESSURE: Normally 3.0 times the maximum dial reading. TEMPERATURE: Not affected by temperatures up to 350°F. VIBRATION: Qualification test report available on pressure tests showing cycling, vibration, to 2,000 cps. at 25 G's, and resonant frequency vibration tests at 25 G's. SHOCK: Data available on MIL-E-5272 shock test. PULSATION: Practically unaffected by line pulsations of 3% of the full dial reading. ENDURANCE: To 250,000 cycles or higher depending on application. ACCURACY: Hysteresis friction and backlash are below readable limits. Absolute gauge accuracy to extremely low limits as required.

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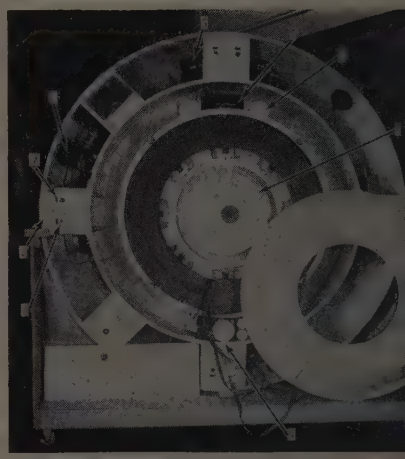

FIGURE 2: GE's one-man space capsule with flared skirt (bottom) and without— (A) infrared attitude sensor, (B) strobe tracking lights, (C) movable periscope and instrument display, (D) C-band telemetry unit, (E) contour-molded seat, (F) descent programer, (G) sequencing valve, (H) dye marker, (I) retrorocket, (J) balloon antenna, (K) fine attitude control jet, (L) roll attitude control jet, (M) coarse attitude control jet, (N) oxygen tank.

The instruments, located in front of the pilot, are rather conventional. However, new instrument accessory systems have been added for detecting and feeding back to the pilot information on items such as jet reaction control, expandable energy remaining, etc.

The X-15 carries two APUs, operated in parallel throughout the unpowered phases of flight. (They can also be used in the event of an emergency to land the vehicle safely).

No performance details have been released on the X-15 APUs, which were developed by GE's Air-

more on page 76

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Separate vs Integral Storage Cooling Systems

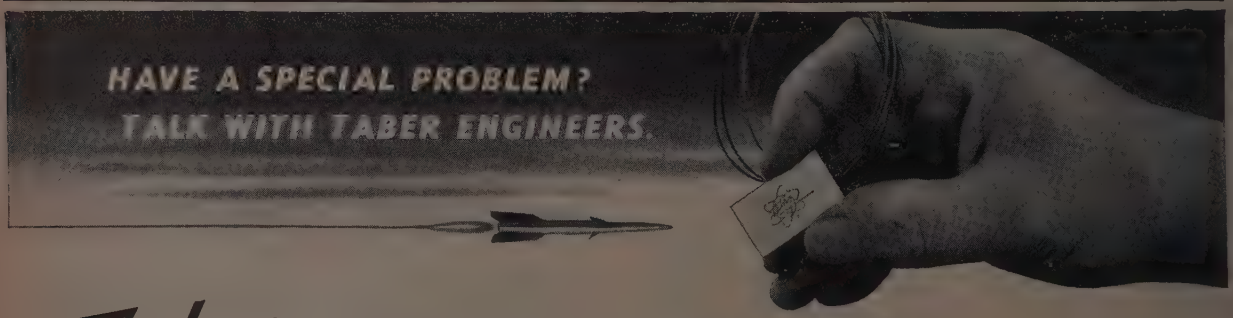
	Separate Storage		Integral Storage	
	Est. Weight (lb)	Est. Volume (cu in.)	Est. Weight (lb)	Est. Volume (cu in.)
Water boiler & tank	61	11,020	59	20,140
Main NH_3 boiler & tank	42.4	3,264	57	5,968
Hydraulic fluid H_2O boiler	3.7	190	*	*
Nitrogen fan & motor	20	485	20	485
Main system controls & valves	4.8	21	2.8	12
Stable platform NH_3 boiler & tank	10.8	805	10.5	1,460
Stable platform system control, valve & pump	3.5	13	2.5	13
Subtotal (dry)	146.2	15,771 (9.1 cu ft)	152.8	28,078 (16.3 cu ft)
Water charge	346.5		410	
Main NH_3 charge	61		73	
Stable platform NH_3 charge	16.8		20	
Subtotal (refrigerant)	424.3		503.0	
TOTAL	570.5		655.8	

*Included with integral water boiler and tank.

craft Accessory Turbine Department. However, it is reasonable to assume that, since the X-15's reaction jets use hydrogen peroxide, the APU could be conveniently powered by the same mixture. There is only one GE APU that meets this condition.

On this basis as well as on that

more on page 80



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When high temperatures and lack of space are your problems, our SUB-MINIATURE MODEL 207S (shown above) is your answer! 400 G's at 2000 CPS., 40 db open loop gain and 20 db closed loop gain, (± 0.5 db, -60° to + 160° C.) Weighs only 0.4 ozs. and contained in Stainless Steel case.

FOR MODERATE TEMPERATURES our Model 196G, 90 db plug-in Amplifier is ideal. 90 db open loop gain, 10 db to 70 db closed loop gain, ± 1% A.C. gain stability -55° C. to + 55° C. 40 G's at 60 cps. 5 V. RMS output 2 cps to 50 KC. Size ⅞" x ⅞" x 2½", weight 1.8 ozs.

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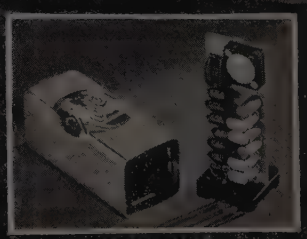

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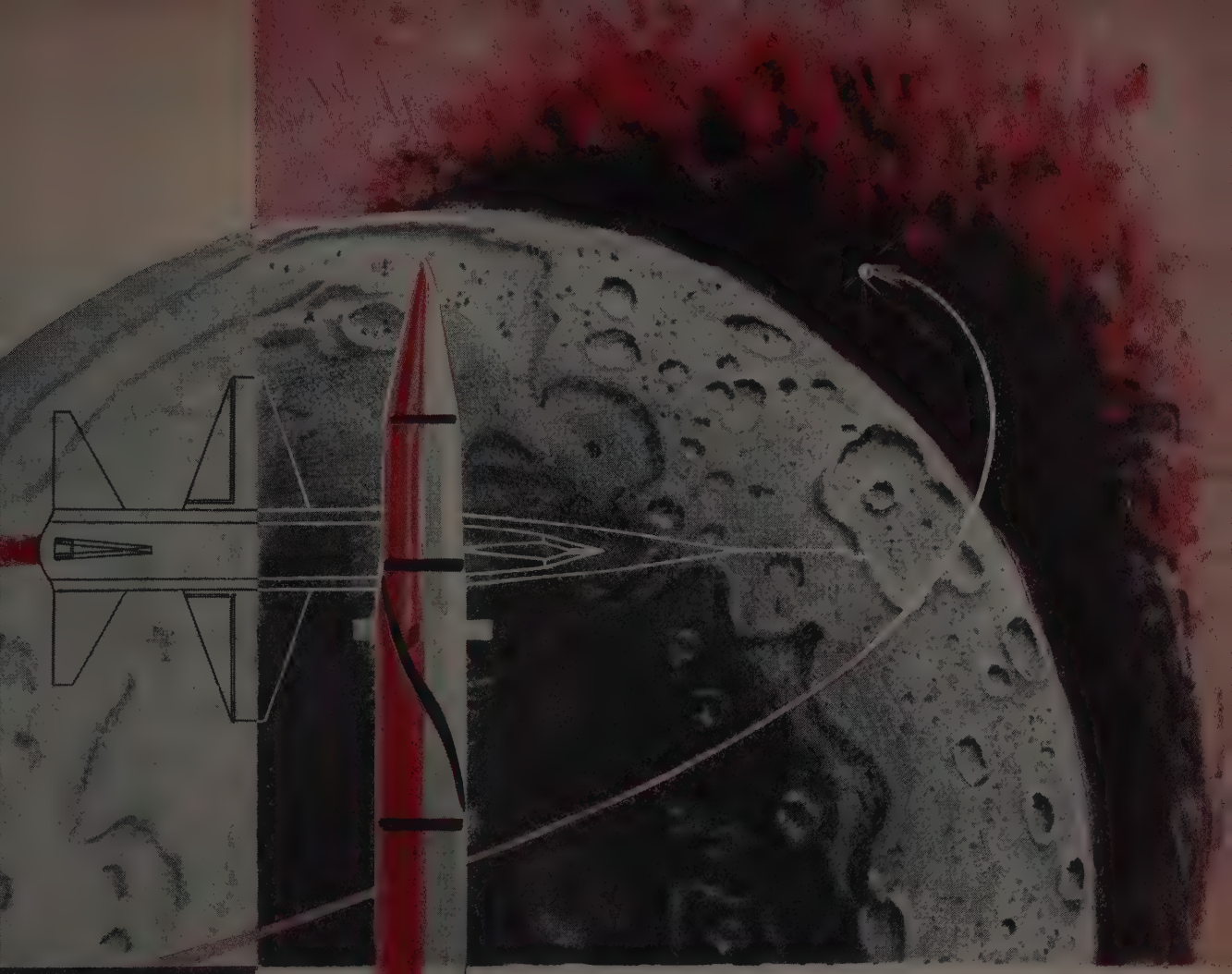

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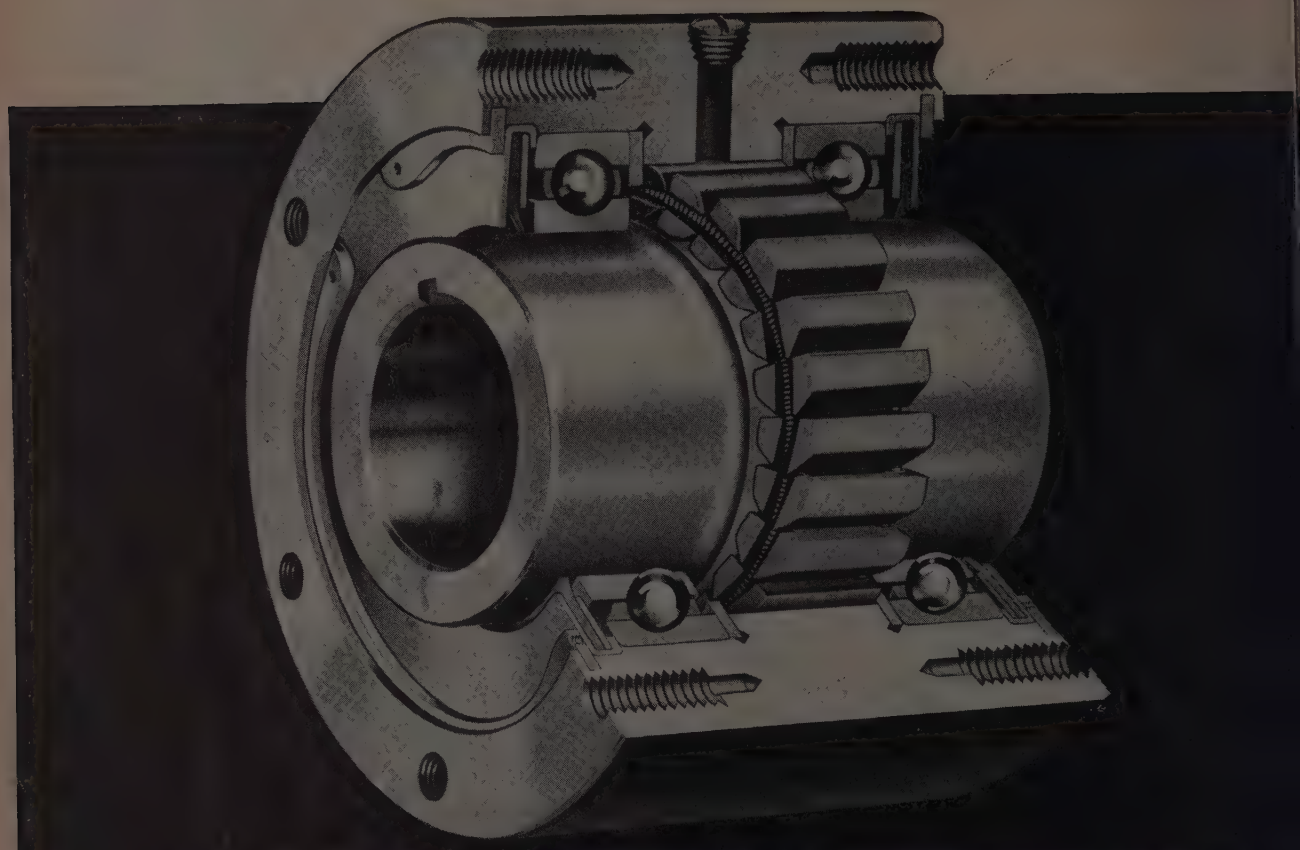
The OVER-RUNNING CLUTCH With



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VERSATILE FORMSPRAG DESIGN MEETS VARIETY OF NEEDS

Formsprag Clutches simplify design problems in missiles, jet and conventional aircraft, and helicopters on over-running, back-stopping and indexing applications. The new aircraft design bulletin "Building More Performance in Less Space" illustrates their use in auto pilots, rudder actuators, canopy actuators, compressors, seat ejectors, gas turbine starters, landing gear actuators, ammunition feeders, etc. Write today for your copy.

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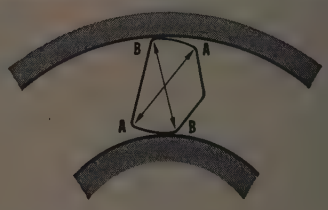

The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

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Per Inch – Per Ounce

How do you pack more performance into less space? More specifically, what clutch gives you more torque, in less space, than ever before available . . . for today's rigid requirements on aircraft and missile applications?

Answer . . . the Formsprag clutch, in a variety of designs and sizes, positively gives you higher torque capacity for its size and weight than any other clutch! In addition, this advanced mechanism features internal simplicity (just four basic parts), no measurable backlash, light weight, compactness, extreme precision and long, trouble-free life. The exclusive, patented Formsprag principle is unlimited in application, yet this full-complement sprag type clutch is extremely simple in design and operation.

Formsprag offers a size and model clutch for every over-running, indexing or back-stopping application. Standard models are available in sleeve bearing, ball bearing, miniature and large bore backstop types. All are illustrated in the new Formsprag catalog, complete with specifications, performance data and design ideas. Formsprag engineers also offer a complete design service on special clutches, including prototype production facilities. Write for the complete Formsprag catalog, or send details of your application for a consultation with the Formsprag Engineering Department.

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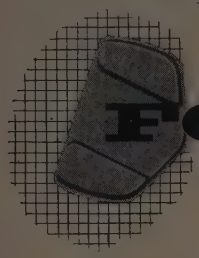
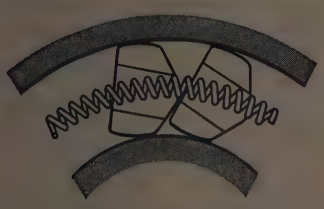
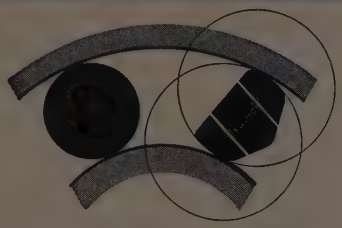


FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

HOW IT WORKS

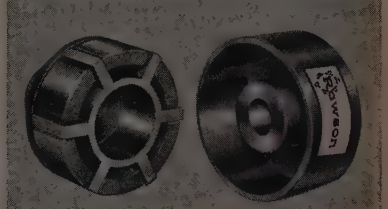




An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

FOR NO-LOAD STARTS



Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.

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of several other characteristics, it can safely be said that the GE power unit is a 40-bhp turbo-drive system. Seven hp goes into driving a four-kva, 400-cps alternator (at 12,000 rpm) and 33 hp into driving a 16-gpm, 3000-psi hydraulic pump (at 3900 rpm).

A fuel modulation speed control technique is used for ± 1 per cent steady state control. The duty cycle is ½—15 hours, and operational life is 150 hours.

Many of the X-15 accessory systems are to be carried over to the Dyna-Soar. To allow for increased maneuverability and flight time, the power output and duty cycle requirements will be boosted.

For short periods—from 30 minutes to perhaps 3-4 hours—Dyna-Soar-type vehicles will have peak power needs ranging from 20 to 200 hp, depending on the vehicle size and mission. (This is the power needed to actuate the stabilization and control systems and to supply their electrical power demands.)

The Dyna-Soar itself reportedly will have jet reaction controls and aerodynamic control surfaces (for re-entry and atmospheric maneuvers) powered by a combined hydraulic and pneumatic system. The environmental control system probably will differ from the X-15's, since the Dyna-Soar will make "extended" flights.

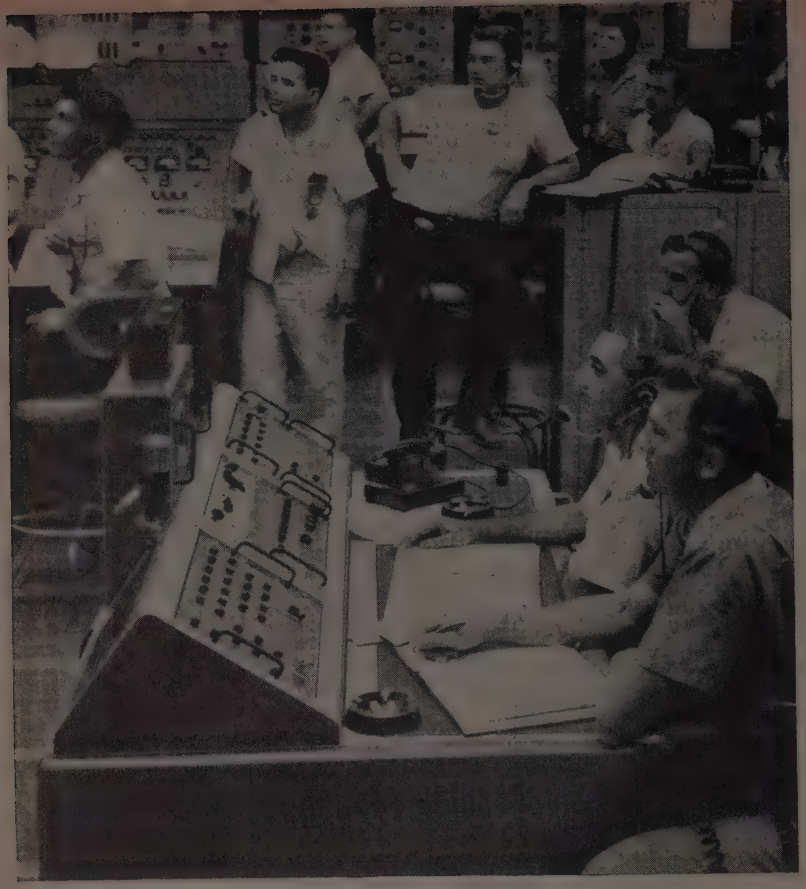
Environmental system for Dyna-Soar type

Hamilton-Standard recently presented an analysis of an environmental control system that may closely approximate the type to be used on the Dyna-Soar. This system was designed for a hypothetical vehicle limited to about four hours unpowered flight in space, with an extra-atmospheric glide of little more than three hours.

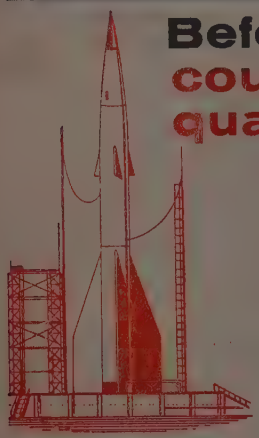
For purposes of illustration, the Ham-Standard engineers divided their vehicle into a manned compartment and two nitrogen-pressurized equipment compartments—a forward compartment containing the bulk of the electronic equipment and a stable platform and an aft compartment containing the rest of the electronic equipment, an APU, and the cooling equipment.

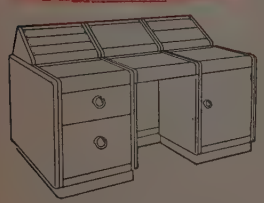
Figure 1 shows the two cooling systems proposed by Ham Standard. The integral-storage system

more on page 83



Before you specify . . . countdown the EMCOR* quality cabinet features





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Thanks to the Air Force's development of *hard-based* missile systems, we have the means to counterattack effectively — *within minutes* — from installations that are virtually invulnerable.

AMF's Greenwich Engineering Division, as the foremost designer-developer of hard-base missile installations, is proud to have helped make the original studies to evaluate these systems, and prouder still of its designs for the Titan and other programs. AMF is the most experienced contractor in the complex and exacting field of hardness engineering.

Missile support specialists will find challenging job opportunities with AMF at several attractive locations — on both coasts!

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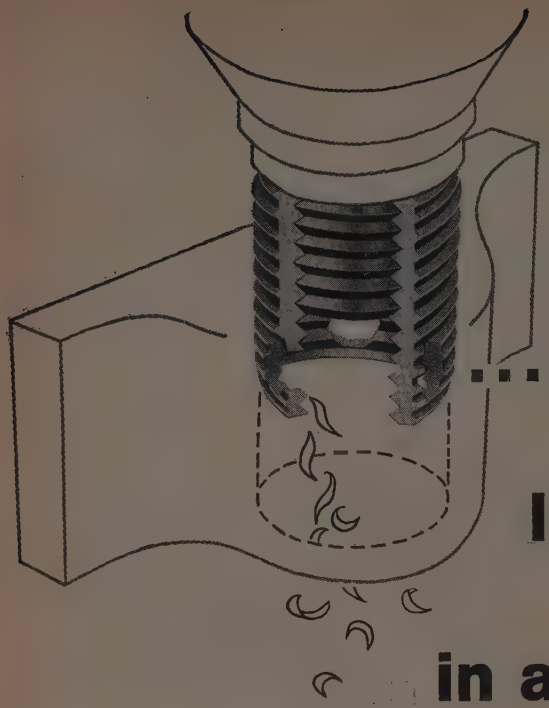


The TAP-LOK® threaded insert ...taps its own thread locks itself in... in a single operation!

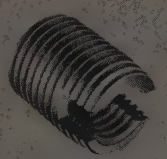
TAP-LOK inserts provide strong wear-resistant threads in relatively soft machinable materials (wood, plastic, aluminum, etc.) . . . as well as in *harder* materials where repeated assembly makes excessive thread wear a problem.

Unlike ordinary threaded inserts, however, TAP-LOK inserts cut their own threads in the parent material. Thus, *no additional assembly time is required* with a TAP-LOK insert.

Its installed cost is the lowest of any threaded insert.

The locking action is achieved in this way: the tapered pilot section carrying the thread cutting edges is followed by the full diameter threads which force their way into the parent material. Once installed, a TAP-LOK insert is permanently locked in place.

Available in the types shown below, TAP-LOK inserts can be used wherever threaded inserts are required. Write today for complete information.



Slotted:—Full V-form external threads provide maximum locking-torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914.

H-Series:— A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

W-Series:—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where strong, permanent threads are required.

P-Series:—This Tap-Lok insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. It is available from stock for standard plug sizes to meet most needs.

TAP-LOK

Another fastener development from—

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(with minimum controls) is said to be the more reliable. However, it involves considerably larger weight and space penalties than the separate-storage system (see *Table*).

In satellites and space probes, the most important accessories will be the power supplies that energize the instrumentation and data transmission equipment. Cooling is taken care of mostly by insulating and radiating structural materials rather than by refrigeration proper.

At present, the most reliable short-term supplies are still the advanced nickel-cadmium and silver-zinc batteries. Solar cells have also been used with great success.

They have reached efficiencies of 10-12 per cent. Further developments reportedly may raise this value to 22 per cent.

Current solar cells weigh in at 1.5 lb/W

Today, about one square yard of sunlit cells will produce 100 W. On a weight-power basis, this comes to about 1.5 lb/W.

These energy sources are satisfactory so long as the power levels of scientific satellites are held to about 100 W. If more than that is needed, other devices must be considered.

For unmanned vehicles—and for emergency use on manned ones—hydrogen peroxide fuel cells may be the answer. These have high power capabilities and efficiencies as high as 70 per cent. However, a lot more development work remains to be done on them. (Many engineers believe that eventually all larger space vehicles will be powered by cryogenic fuel cells.)

Nuclear power sources also might meet higher power demands. The Atomic Energy Commission has been supporting work on them for some time now.

Three separate projects were started to develop a *S*ubsystem *N*uclear *A*uxiliary *P*ower source (Snap-1, -2, and -3). The results of Snap-3, the most ambitious program, which aimed at the direct conversion of nuclear energy into electricity, were successfully demonstrated early this year.

The prototype model of the Snap-3 system was developed by Martin and Minnesota Mining & Manufacturing. Basically, it is a radioisotope - fueled thermoelectric generator.

more on next page

project:
BUILDING COMMUNICATIONS SYSTEMS AT 60 mph

FRI's Flying Cable Cartridge allows complete network to be laid by helicopter

Previously, communications cable was fed out from uncontrolled reels. However, when the cable hit a snag, the reel fed out too quickly. The cable cascaded, tangled—or broke. Flight Refueling, Inc., in conjunction with ITT Laboratories, designed and manufactured a complete package that feeds the cable out smoothly, evenly . . . and fast . . . no matter how rough the terrain.

This is only one of the many controlled airborne suspension projects from FRI. Others include design study of equipment for towing targets at high speeds, trailing dip sonar systems and fire-fighting packages for transportation into stricken areas by helicopter.

If you have a problem in the area of controlled airborne suspension, Flight Refueling, Inc. has the facilities for the design, testing and manufacture of simplified, practical solutions. Write for literature.

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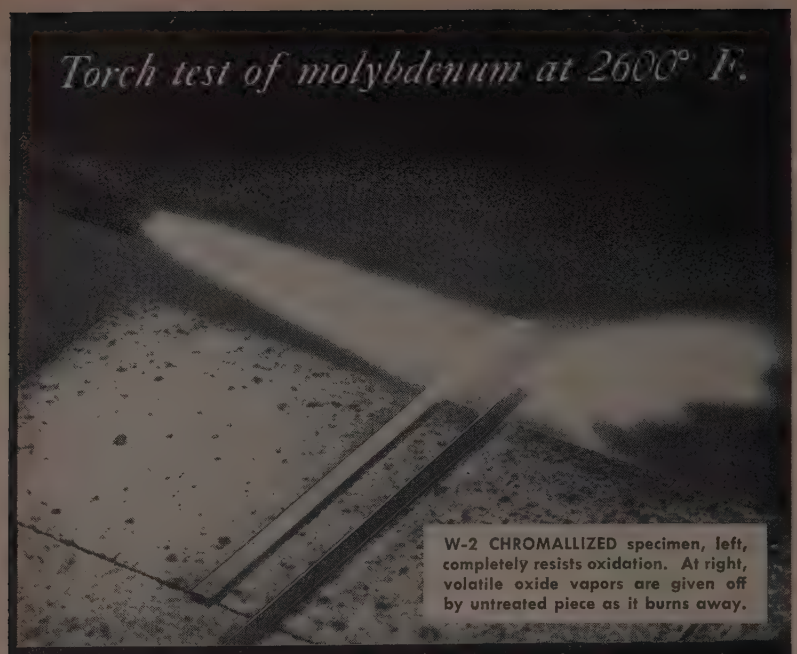
Torch test of molybdenum at 2600° F.
W-2 CHROMALLIZED specimen, left, completely resists oxidation. At right, volatile oxide vapors are given off by untreated piece as it burns away.

CHROMALLIZING
FOR METAL PROTECTION
AT JET-HOT TEMPERATURES

Improve oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications with CHROMALLIZING. This patented method of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

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The radioisotope is polonium 210. The prototype system has only a half charge of polonium and weighs about five pounds (including shielding) and produces about 2½ W of electricity. It is about 4¾ in. in diameter and 5½ in. high.

With a full 3000-curie charge of polonium (the value for which the system is designed), the output could be pushed up to about five watts. AEC officials also believe the weight of the more powerful system could be cut to three pounds.

At the end of its first half-life, the prototype Snap-3 is expected to deliver 2000 W-hr/lb over 140 days. This would fall off to 900 W-hr/lb in the next half-life or 140 days.

The electric conversion efficiency of the half-charged Snap-3 system is 5-6 per cent. The development engineers think they can get this up to perhaps 11 per cent.

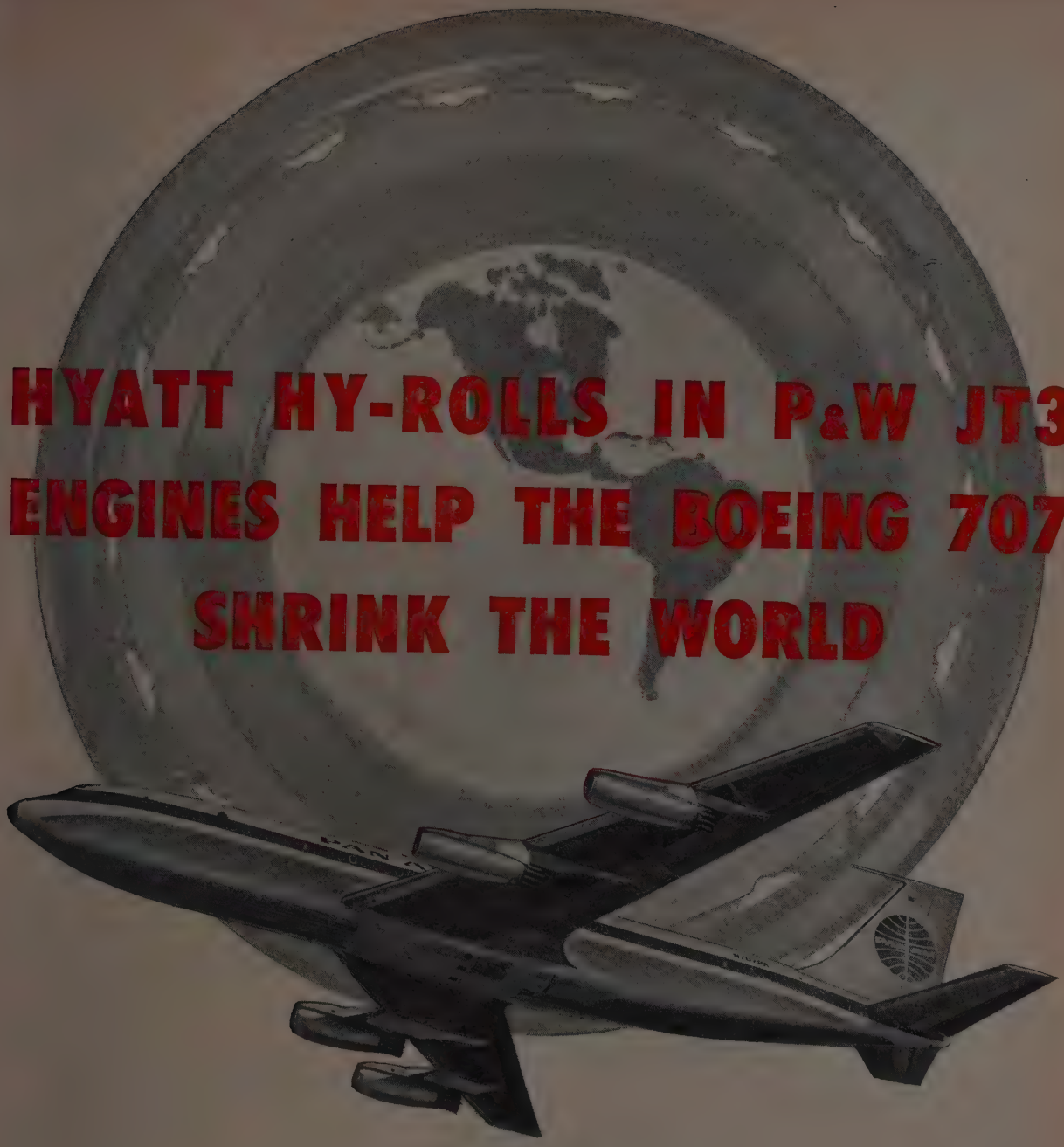
Space applications of the nuclear generator system right now are limited to energy levels below 1000 W. However, better thermoelectric conversion efficiencies could up this value.

Little is known about the design details of the NASA capsule to be developed and built by McDonnell. However, many companies have been working out detailed designs of manned space capsules that are probably quite similar.

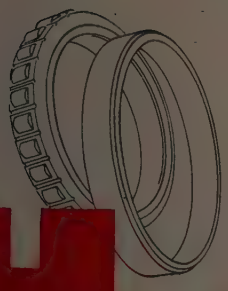
One capsule design (see AVIATION AGE' *"Missile - Launched Manned Space Capsule," Aug. '58, p. 172*) would carry about 100 lb of air conditioning, 150 lb of liquid oxygen (LOX) and helium storage tanks and evaporators, and 200 lb of non-propulsive power. Hydrogen peroxide burning reaction jets would be used for attitude control.

GE's Missile & Space Vehicle Department is among the groups that have worked out detailed designs of one and two-man space capsules. In its one-man design (*Fig. 2*), several accessory components are integrated to function as related subsystems. These include infrared attitude sensors (tied into fine and coarse attitude control reaction jets), C-band telemetry units, 120 lb of batteries, parachute recovery programer, gas generators, strobe tracking lights, LOX tanks, beacon transmitters, etc. The overall weight of the capsule, including pilot, is about 2200 lb.—End

HYATT HY-ROLLS IN P&W JT3 ENGINES HELP THE BOEING 707 SHRINK THE WORLD



HYATT HY-ROLL BEARINGS in each of the 4 Pratt & Whitney JT3 jet engines help the Boeing 707 cruise smoothly at 600 mph. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.



Another GM GENERAL MOTORS contribution to aviation progress

HYATT HY-ROLL BEARINGS FOR AIRCRAFT INDUSTRY

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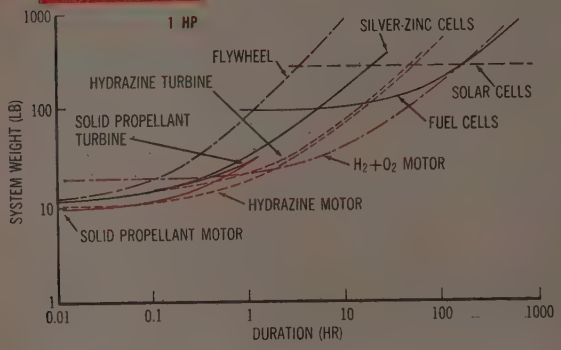


Evaluating APU systems for spacecraft

The choice of auxiliary power systems for space vehicles is bewilderingly wide—it ranges all the way from such standbys as the silver-zinc battery to "blue sky" solar and nuclear devices. Which approach is best for which mission? Here is a review of APU systems that points the way to the answer to this tricky question.

by S. L. Sandelman and R. W. McJones
Preliminary Design Engineers, Aero Hydraulics Div., Vickers Inc.[1]

THE choice of auxiliary, or non-propulsive, power sources for spacecraft largely depends on the optimization of the overall system into which they must be integrated. It is necessary, therefore, to have a clear idea of the various typical auxiliary power systems that are suitable for use in space.

Electrochemical power systems use stored chemical energy. This is converted directly into electric energy in cells or batteries. In conventional "wet" and "dry" cells, a fixed amount of reactive material is built in.

(1) Aero Hydraulics Div., Vickers Inc. (Div. of Sperry Rand Corp.), Detroit 32, Mich.

more on page 88

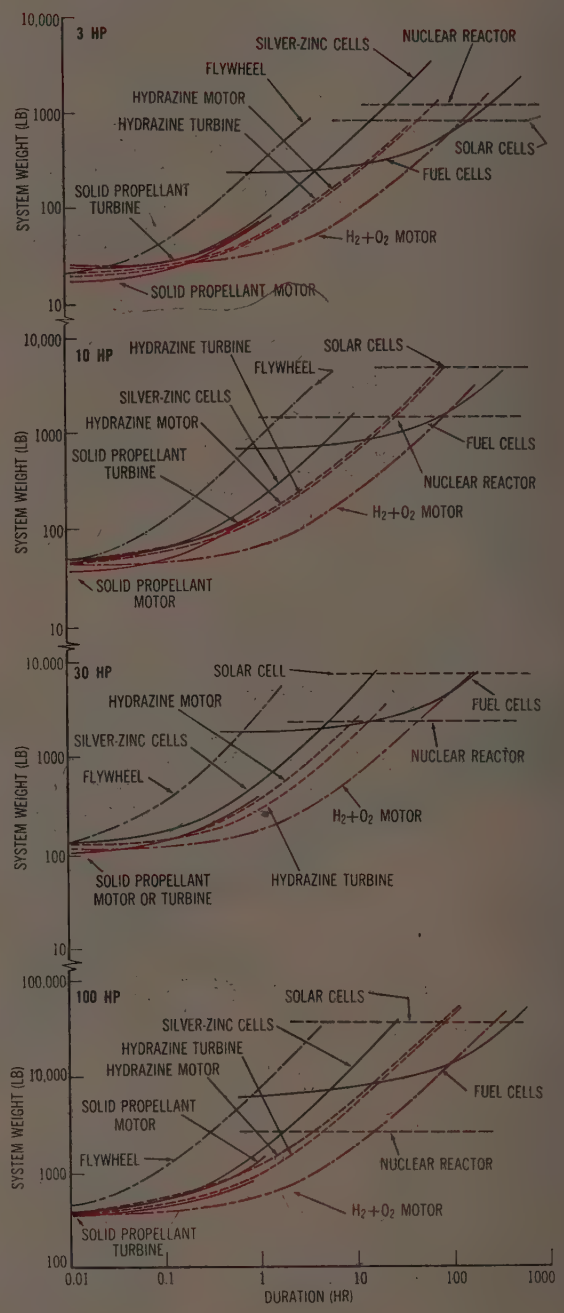


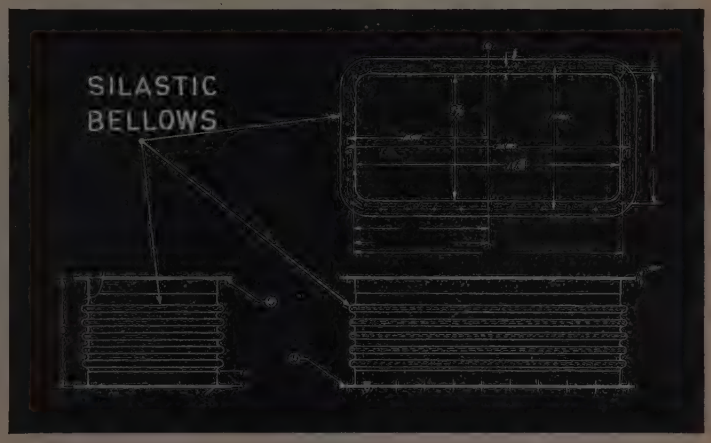
FIGURE 1: Weight comparison of auxiliary power systems for spacecraft at various power levels. The curves represent installed weight only for very short periods; as duration increases and the slopes of the curves become constant, specific propellant consumption is shown (installed weight having become insignificant).

The PLANE

Douglas' C-133A, powerful long-range transport on duty with the USAF. Designed primarily as a logistics airplane, the C-133A can also be modified to carry over 200 fully armed troops. Power: four Pratt & Whitney T34 turboprop engines. Range: over 4,000 miles with 40,000 pounds or 1,600 miles with 94,000 pounds.

The PROBLEM

Developing heating system ducts that would not be damaged by vibration. Originating under the turboprop cowls, the ducts must withstand not only vibration but heat as well. A rubber bellows would solve the shock absorbing problem . . . but ordinary rubber can't take the high temperature.



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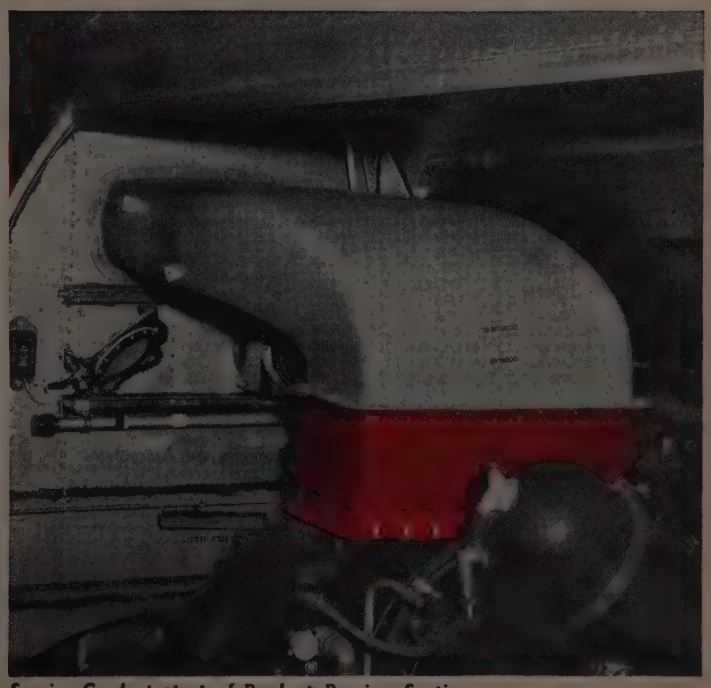

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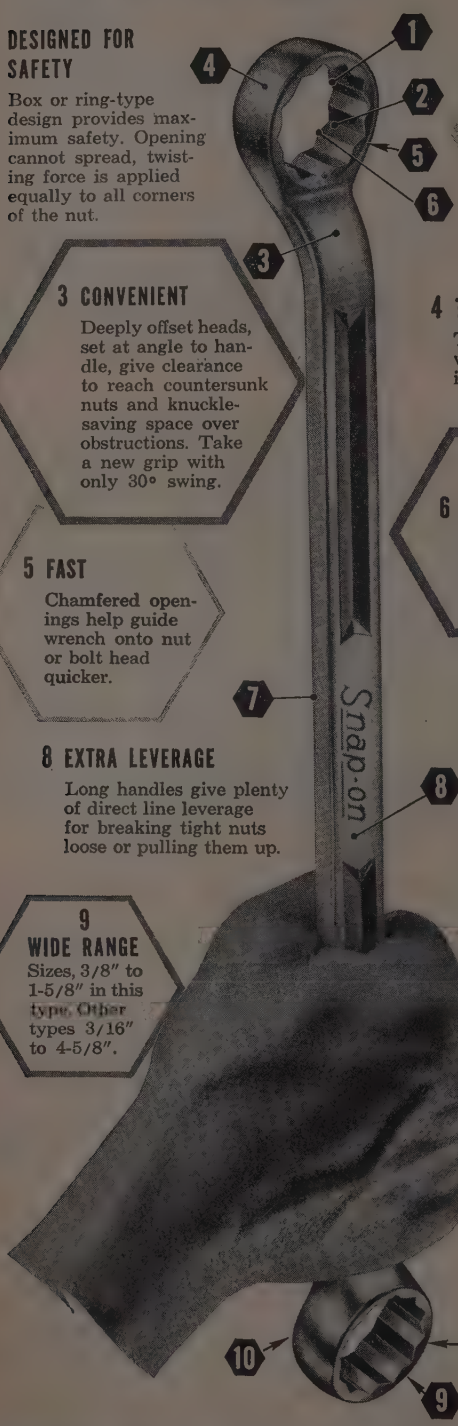

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5 FAST

Chamfered openings help guide wrench onto nut or bolt head quicker.

6 MULTI-USE

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7 COMFORTABLE

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8 EXTRA LEVERAGE

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9 WIDE RANGE

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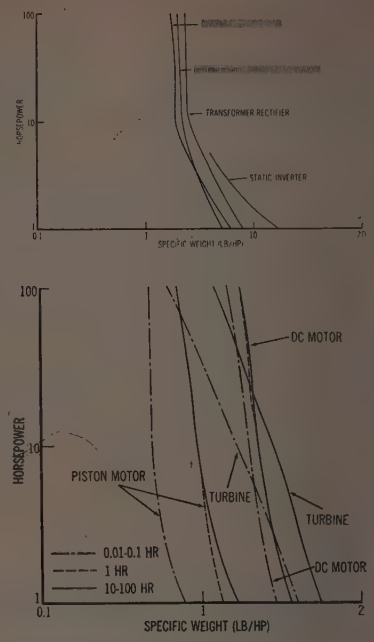

FIGURE 2: Specific weight of APU system components for various durations.

With certain recent "fuel cells," gaseous reactants are introduced into the cell as needed. Conventional cells—such as silver-zinc—offer the lowest specific weight.[2]

There is a fixed battery weight for a given horsepower at time equals zero. This is because it takes a given cross-sectional cell area to develop the required power. Thereafter, more cell weight is added for a duration factor. Conventional cells can be characterized by a fixed weight of 1-2 lb/hp plus a power-duration weight of 12-18 lb/hp-hr.

Fuel cells convert fuel directly into electricity. Unlike conventional batteries, they remain essentially unchanged during their operating life. Hydrogen and oxygen enter the cell through hollow electrodes and diffuse through porous carbon to the surface. There they come into contact with the electrolyte.

At the hydrogen electrode, the electrochemical reaction with the potassium hydroxide produces water and releases an electron that enters the electric circuit. The

(2) The values used here are for secondary (rechargeable) cells. They do not include the electrolytic injection mechanism required with primary cells.

more on page 90

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electron flows through the external circuit, and returns to the cell at the oxygen electrode. There, in the electrochemical reaction of the oxygen and the electrolyte, the electron is accepted. Ionic conductivity through the electrolyte completes the electric circuit.

The main limitation of the fuel cell at present is its large weight-horsepower ratio. (To save tank weight and volume, the hydrogen and oxygen fuel is stored as a cryogenic fluid.) Performance is believed to involve fixed weights of 55-75 lb/hp and power duration weights of 0.8-2 lb/hp-hr (including reactants and tankage).

With electrochemical systems, dc electric power is taken right from the cell. Hydraulic power is obtained from dc-motor-driven pumps. AC power comes from motor-driven alternators above and from static inverters below one hp.

Solar systems can use the sun's radiant energy (about 420 btu/hr/sq ft at the earth's orbital distance) when the space vehicle is not in shadow. An ideal conversion device would require six square feet of receiving surface for each horsepower generated. Actually for currently projected devices this value will be 50-100 sq ft. Solar energy can be converted through closed expansion cycles, thermocouples, and direct photoelectric cells.

The expansion and thermocouple approaches involve cold-end radiators whose size and weight are hard to predict. Therefore we'll work here with semiconductor photoelectric cells at an estimated specific weight of 100 lb/hp.

Since many early space vehicles will orbit the earth, they will be in the shade about half the time. We shall assume a 90-minute orbit with double capacity solar cells and enough silver-zinc cells to store power for 45 minutes of shaded operation. The specific weights assumed for alternator and inverter are as shown in *Figure 2*.

Nuclear systems may use closed expansion cycles, thermocouples, and possibly some form of direct nuclear-electric conversion cells. Only for the first two types can weights be estimated now, and even in these cases the values for radiators and shielding are speculative.

We will assume here a closed-cycle expansion process with a shielding allowance that may or may not be enough for manned vehicles. The weight of this system is taken as 25-1000 lb/hp, depending on size. (The system won't run indefinitely without fuel replacement, but the duration factor is small compared with the uncertainty in fixed weight.)

Flywheel systems look good for short durations

Mechanical systems use energy stored in flywheels (springs are far too heavy). They are attractive for short durations, with weights of 74 lb/hp-hr plus the fixed weight of hydraulic pumps and electric generators.

Gas expansion systems can use a variety of energy sources: stored gas, solid propellants, and liquid mono- and bi-propellants.

Compressed gas storage systems have a final working fluid housed

more on page 92

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ENGINEERING NEWS

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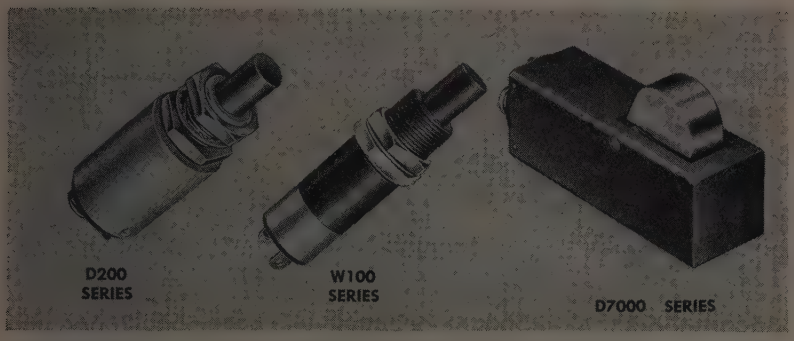

For heavy-duty limit or positioning applications, Hetherington offers a variety of special switches with ratings from 10 to 35 amperes.

Pushbutton types, such as the slim, 9/16″ diameter "W100" Series or the 35-amp "D200" Series, feature short, unusually sturdy plungers that afford positive direct operation in minimum space. Threaded aluminum bushings provide easy mounting and positioning.

Where switches must operate against sliding surfaces, the cam-operated "D7000" Series proves ideal for many applications. Flush mounting, and only 2-27/64″ long by 3/4″ square, this small switch has a polished stainless steel cam which retracts within 1/32″ of the switch body. Over-travel is 9/32″ minimum.

Like most Hetherington products, Limit Switches use Hetherington's tease-proof, double-break, snap-action mechanism. A variety of single-pole contact arrangements are available on each type. Switch mechanisms are effectively sealed against dust and moisture by integral anodized aluminum housings. Cases are especially rigid to withstand severe service.

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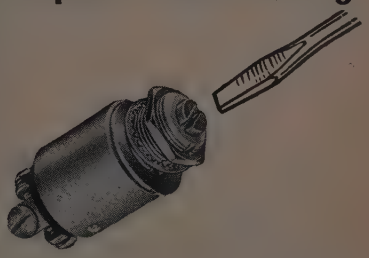

An aircraft equipment manufacturer needed a small, yet high current switch that could be concealed for use only during installation or routine maintenance testing of his equipment. The answer was the Hetherington Type R1043—a screwdriver-operated version of the popular R1000 Series Rotary Switch.

Accessible, yet readily hidden behind the chassis, the R1043 allowed easy circuit transfer from "Operate" to "Test" with far greater reliability than the space-consuming, jumper-type test fittings previously used.

Only 3/4″ in diameter, the R1043 rotary switch breaks 20 amps (resistive) at 28v dc. In spite of its size, the positive snap-action assures adequate leverage to break contact welding from overloads.

No bulletin is available on the R1043, but dimensions, ratings and contact data will gladly be sent.

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Lamp burn-outs and circuit failures can present real hazards in critical warning light applications. To minimize the danger, the Hetherington L3000 Series allows the lamp and its circuit to be checked at any time merely by pressing on the spring-mounted plastic lens.

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Details on the L3000 line are in Hetherington Bulletin L-1a. Small quantities of Type L3000R (red lens, 28v) are stocked by many leading electronic parts distributors.

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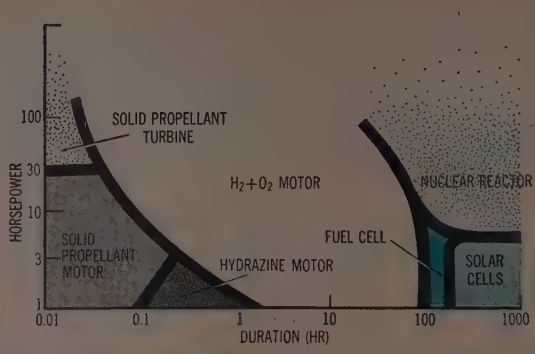

FIGURE 3: Optimum weight areas of spacecraft APU systems. Load division is 50 per cent hydraulic, 25 per cent ac, and 25 per cent dc.

in either air bottles or in hydraulic accumulators. In both cases, the specific weight is very high—690 lb/hp-hr and at least 1400 lb/hp-hr, respectively.

Two big reasons for considering solid propellants are simplicity and reliability. However, there are some drawbacks, too—solids rank below liquid propellants in specific energy content, and their burning rate is hard to vary.

We shall here work with AOJ as a representative solid propellant. It has an ideal sfc of 3.7 lb/hp-hr. (For very long durations, it should be noted, a solid becomes impractical because of the large pressurized volume and hence container weight.)

Among known mono-propellants, hydrazine is most attractive. Its drawbacks are that it is toxic as a fluid and that it has a high freezing point of +34 deg F.

more on page 94

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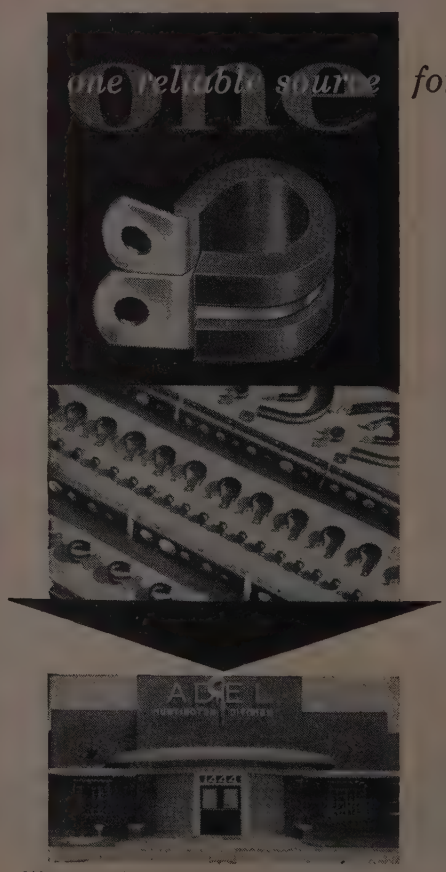

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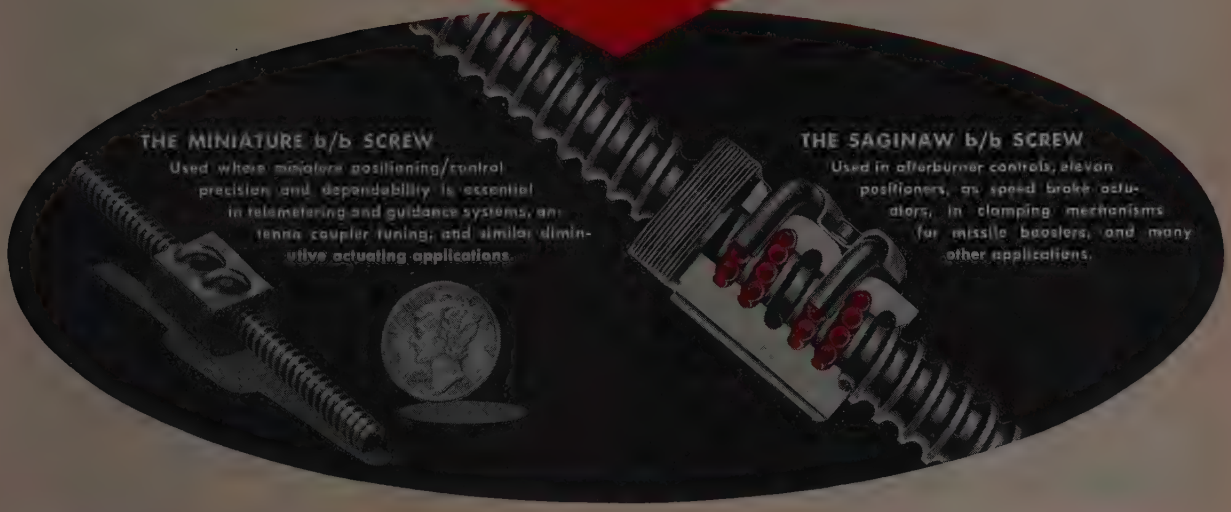

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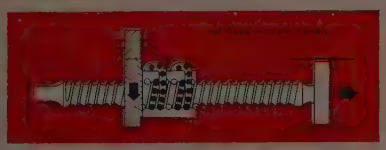

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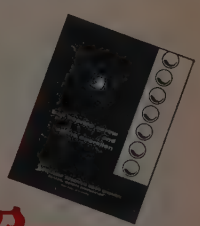

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—3/16 to 10 inches in diameter.

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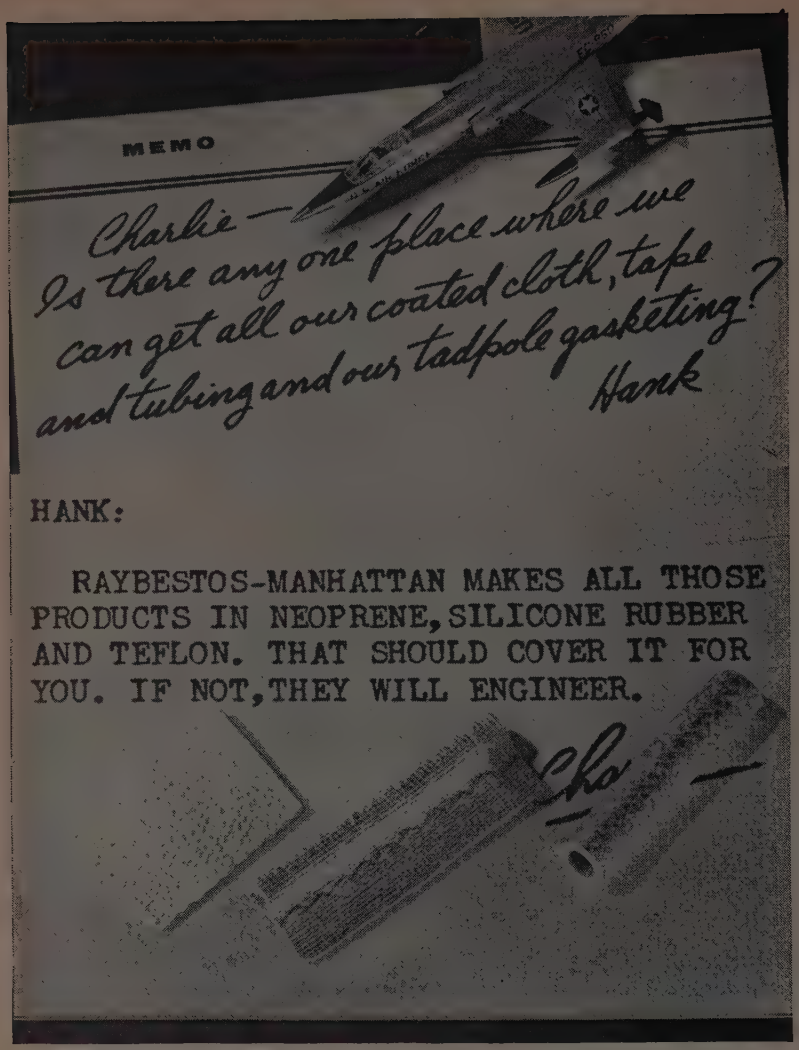
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The ideal of 3.4 lb/hp-hr is used here as representative over pressure (expansion) ratio range from 20 to 30. For short durations, the fuel tank is considered as a pressurized vessel; the tank weight then is assumed to equal the fuel weight. A fuel pump is assumed for longer durations, with tank weight taken as 10 per cent of the fuel weight.

Stored energy is large per unit weight

Bi-propellants look good for long ranges because of the large stored energy per unit weight. Other advantages, in addition to low sfc, are: that bi-propellants can be used for cooling, have excellent heat transfer qualities, and provide easy combustion (with a wide range of mixtures) and reducing (non-oxidizing) atmospheres for working parts.

Hydrogen and oxygen were chosen as the bi-propellant fuels for our study on the basis of sfc—about 1.35 lb/hp-hr—and heat sink capabilities (most important for intermediate range space missions). Liquid hydrogen shows high heat absorption per pound and high available power per pound of fuel. It also is a logical choice whenever vehicle cooling and the power supply functions may be combined.

Low pressure vessels cut weight and size

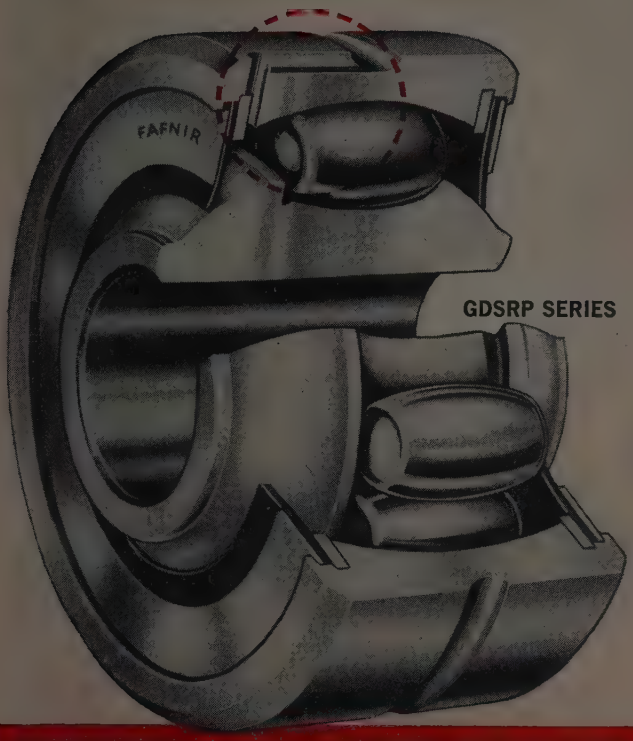
Minimum tank weight and size are big advantages of low pressure fuel vessels. They also can keep fuel in a cryogenic state by using the heat of evaporation.

Our other assumptions for this evaluation are:

- The load division is 50 per cent hydraulic and 50 per cent electric (25 per cent ac and 25 per cent dc). The exact division actually does not materially affect total weight.
- Heat exchangers correspond in design and construction to the present state of the art for compact heat transfer surfaces.
- For systems under 10 hp, a positive displacement motor is the prime mover that is basically a modified standard hydraulic aircraft unit now in production.
- For short duration, full admission is used, because fuel weight

more on page 97

NEW DESIGN PERMITS RELUBRICATION OF FAFNIR HIGH-CAPACITY CONTROL BEARINGS



GDSRP SERIES

Fafnir DSRP control bearings, featuring "most capacity for weight and size," now offered in new GDSRP relubricatable series

An outer ring groove and ports for bearing relubrication have now been designed into Fafnir high-capacity control bearings. With these added features, bearings will be identified as the GDSRP Series. Bearing dimensions, features, load ratings and life factors are the same as the DSRP Series. Detailed information on the new relubricatable series is available. Write for bulletin. The Fafnir Bearing Company, New Britain, Connecticut.

Here is what the new Fafnir GDSRP Control Bearings offer you . . .

1. Relubrication — Grooves and ports permit access of lubricant to rollers and raceways. Ports are drilled outside of bearing load zone-do not affect load-carrying capacity.

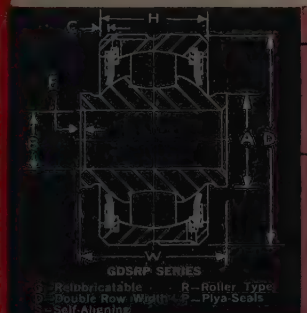
2. Balanced Design —"Excess baggage" eliminated, to bring bearing components into perfect balance with bearing capacity. One piece inner and outer ring design saves space, weight.

3. High-Capacity Construction — Full complement of barrel-shaped rollers; large roller-to-race contact areas; no retainer.

4. Hardened Back-Up Rings — provide positive shoulder stops independent of the seal rings... prevent seal damage in event of severe misalignment.

5. Removable Fafnir Plya-Seals — Seals are securely anchored in outer ring grooves — provide maximum protection against dirt, moisture and abrasive contaminants.

6. Exposed surfaces cadmium plated to withstand corrosive conditions. Snap rings are stainless steel.



	B	D	W	H	A	E	C				
						CORNER CHAMFER X-45°					
BEARING NUMBER	BORE +.0000 −.0005 INCHES	O. D. +.0000 −.0005 INCHES	WIDTH INNER RING +.000 −.005 INCHES	WIDTH OUTER RING +.000 −.005 INCHES	SHOULDER DIAM. INNER RING (APPROX.) INCHES	INNER RING BORE +.015 −.000 INCHES	OUTER RING O. D. +.015 −.000 INCHES	ROLLERS NO.	ROLLERS DIAMETER INCHES	RADIAL LIMIT LOAD RATING (POUNDS) †	WEIGHT POUNDS (APPROX.)
GDSRP4	.2500	.9014	.625	.464	.404	.005	.032	12	.1514	3025	.06
GDSRP5	.3125	1.2500	.812	.656	.515	.015	.032	11	.2303	7350	.16
GDSRP6	.3750	1.4375	.937	.750	.564	.015	.032	11	.2681	9600	.24
GDSRP8	.5000	1.6875	1.000	.812	.775	.015	.044	12	.3023	12500	.36
**GDSRP10	.6250	1.9375	1.125	.937	.869	.015	.044	14	.3016	17700	.55
**GDSRP12	.7500	2.3750	1.312	1.125	1.150	.015	.044	13	.3900	26900	—

Permissible misalignment 10° in either direction

All dimensions in inches. Bearings interchangeable dimensionally with AN206 DSP Series Bearings

**Will be made as demand justifies tooling

†Thrust limit equal to 30% of radial limit load rating

FAFNIR
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- Both Damping and Integrating types available with parameters to your requirement.
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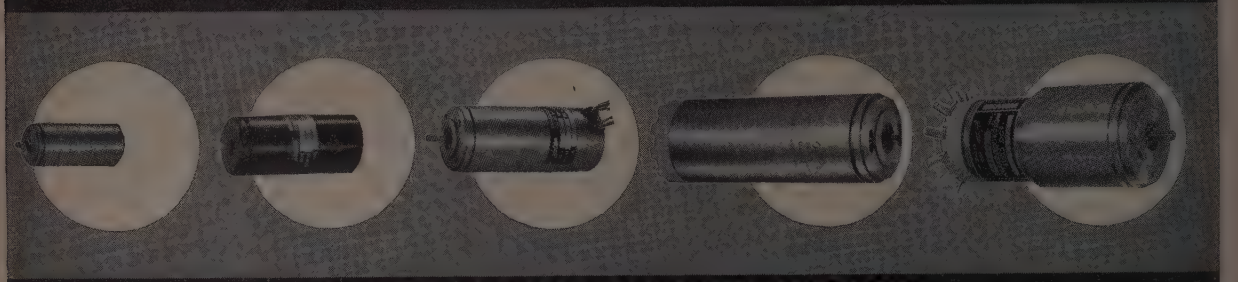

400 CPS SERVO MOTOR – TACHOMETER GENERATORS

Oster Type	Size	Length Inches	Wt. Oz.	Rotor Inertia gm cm²	MOTOR					GENERATOR				
					Rated Voltage		No load speed RPM	Watts per phase @ Stall	Stall Torque OZ. IN.	Excit. Volt.	Output Volts per 1000 RPM	Lin.% to 3600 RPM	Null MV	Phase Shift @25°C
					Ø 1	Ø 2								
8MTG-6201-01	8	1.850	2.3	0.77	26	40/20	6,500	2.2	0.16	26	0.25	0.5	15	± 5°
*10MTG-6228-02	10	2.157	4.2	0.72	115	115/57.5	9,500	2.8	0.26	115	0.45	1.5	19	±10°
10MTG-6229-12	10	2.100	2.9	1.09	33/16.5	52/26	9,500	3.0	0.28	26	0.45	1.5	13	±10°
*10MTG-6229-03	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	16	0.3	1.5	12	±10°
10MTG-6229-15	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	26	0.3	1.5	12	±10°
*10MTG-6232-05	10	2.104	4.2	1.1	115	36/18	6,500	3.5	0.26	115	0.30	1.5	15	±10°
11MTG-6251-13	11	2.531	7.0	1.3	115	115/57.5	6,500	3.5	0.63	115	0.55	0.5	19	±10°
11MTG-6251-00	11	2.531	7.0	1.1	115	40/20	6,500	3.5	0.63	115	0.55	1.5	19	±10°
11MTG-6254-01	11	2.200	6.0	1.1	115	115/57.5	6,500	3.5	0.63	115	0.55	1.5	19	±10°
15MTG-6280-01	15	3.281	14.0	5.3	115	115/57.5	5,000	6.2	1.5	115	3.0	0.2	13	± 5°
†*15MTG-6276-03	15	3.875	15.0	4.4	115	57.5	8,500	5.8	0.70	115	2.75	0.2	13	± 0.5°
18MTG-6302-02	18	3.680	20.0	5.7	115	115/57.5	9,000	16.0	2.7	115	3.0	0.2	13	± 5°
18MTG-6302-04	18	3.680	20.0	5.7	115	115/57.5	4,800	9.2	2.4	115	3.0	0.2	13	± 5°

*These units designed for 85°C ambient but same characteristics can be designed for 125°C. †Additional 21.4 watts for heater, the values given are independent of ambient temperature.

Other products include servos, synchros, resolvers, motor-gear trains, AC drive motors, DC motors, servo mechanism assemblies, reference and tachometer generators, servo torque units, actuators and motor driven blower and fan assemblies.

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Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

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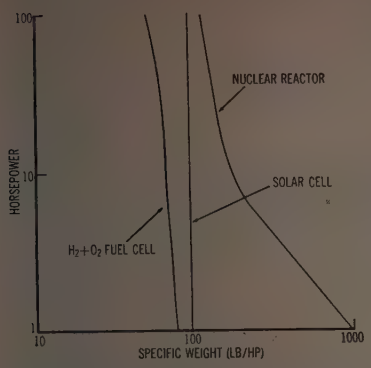

SPECIFIC WEIGHTS of three APU systems for durations of 10-1000 hours.

is small in relation to unit motor weight. Overall efficiency is limited to about 40 per cent.

• For longer durations, internal expansion is provided, leading to overall efficiencies of about 70 per cent. As there is a wide choice of fully developed units for various power levels, performance is basically constant, and no scale factor for power level is needed.

• To optimize system efficiency at 10 hp and higher, an expansion engine is used for low-bmep operation that is largely similar to the external combustion devices of the "steam engine" type. There is a definite scale factor with horsepower level, and specific weights as low as 0.5 lb/hp at about 40 hp can be had.

• Turbine efficiencies are based on a pressure ratio range from 20 to 30 and reflect the current state of the art. Efficiencies are as low as 40 per cent at short duration and low power, and go up to 85 per cent at higher power and longer duration.

Installed weights include gear boxes to drive standard 400-cycle generators at rated speed.

Figure 1, compares the weights of the systems we have discussed. *Figure 3* shows the areas of applications in which each of the system is the lightest available. In general, however, other systems besides the lightest one can be used at relatively small weight penalties in each of these areas. At times, one of these may be more attractive on the basis of logistics, development time, or for some other good reason. Regions near the system weight intersections especially are doubtful on this score.—End

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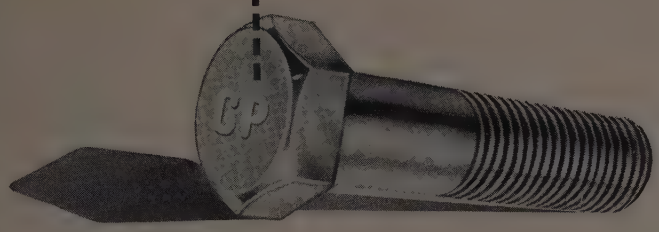

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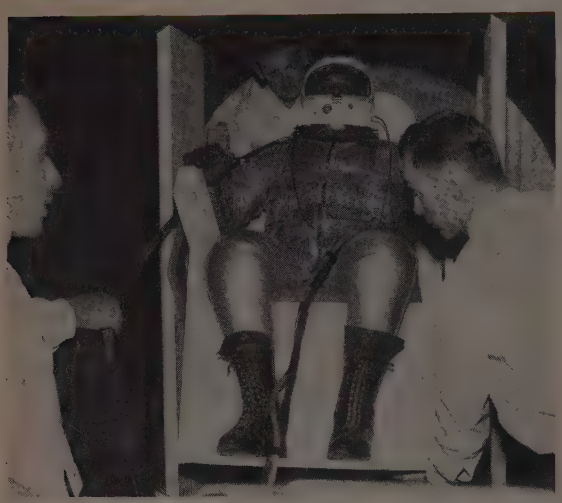

SPACE PILOT is fitted for molded seat in capsule developed by GE's Missile & Space Vehicle Dept. Pilot's suit is AF's latest maximum G and temperature model.

Properties of Earth's Radiation Belts*

	Hard (Cosmic Ray) Radiation	Soft (Auroral) Radiation
Origin	decay of cosmic ray albedo neutrons coming out of earth's atmosphere	solar corpuscular streams, with subsequent acceleration near earth
Nature	10-400-mev protons	electrons & protons of less than 1 mev
Shielding	hard to absorb & shield	easily absorbed
Location	equator & low altitudes, close to earth	auroral latitudes, far from earth
Time dependence	constant in time	variable, increases when sun is active

*From studies by Dr. Fred Singer, U. of Md.

State of the art: Human factors

- **Hard radiation will cause most trouble**
- **Manned capsules to test weightlessness**
- **Hermetic cabin sealing seen feasible**

VIRTUALLY all experts agree that man can survive in space. A comparison of man's capabilities with those of machines further shows that he will really "pay his way" in space—he will be able to function usefully and so add to the reliability of the space system.

The aim of all our present research into manned space flight is to find out how far man will be able to exercise his capabilities in the artificial and hazardous environment of the space vehicle.

Probably the most important recent advance in this direction was the discovery of the Van Allen belt by the Explorer satellites and the Pioneer probes. Van Allen's latest data from Pioneer III indicate two radiation belts, centered within two strata (1400-2400 and 8000-12,000 miles) and surrounding most of the earth's atmosphere. They consist of charged particles temporarily trapped in the earth's magnetic field.

According to Dr. Van Allen and his instrumentation specialists at the University of Iowa, we still don't know the spectrum range of this radiation. Not even the particles have as yet been identified. The more penetrative components could be X-rays (produced by solar beta rays striking the hardware of the spacecraft) and protons presumably in the 4-100-mev energy range. Most physicists agree that we could get more positive identifications by sending a sampling probe straight through the belts up to at least 11 earth radii and then have it return along the same path.

Theoretical studies by Dr. Fred Singer at the University of Maryland have produced results that tally closely with the data collected by Van Allen. They indicate there may be a hard radiation belt of cosmic ray origin and a soft one of solar origin and associated with magnetic storms and auroras.

more on page 100

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for transport, storage and ground handling of
in-flight refueling stores,
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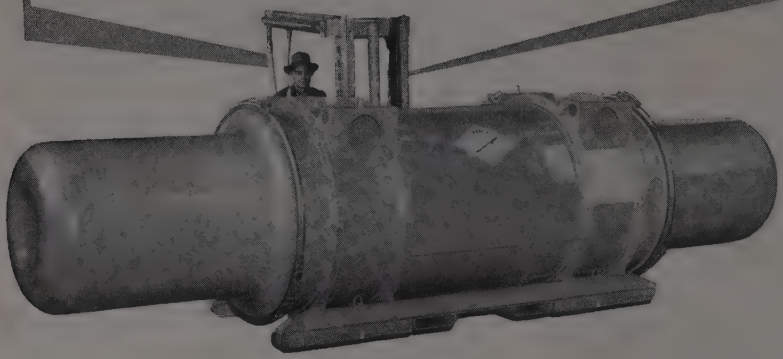
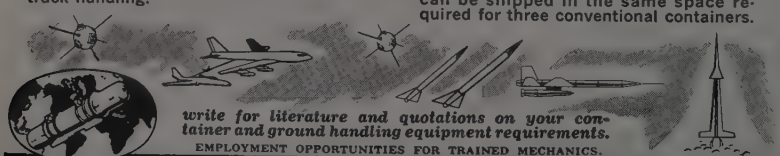
jet engines...accessories
60% LIGHTER IN WEIGHT!



HARCO CONTAINERS ARE THE *ONLY*
fiberglass containers approved by BuAer for handling in-flight refueling stores. Far lighter in weight than steel containers, they also transport the Harco developed ground handling trailer for moving of stores from container to aircraft. Type 1500 Harco Container is 18½-feet long, 4½-feet diameter. Unique design of end sections permits reversing and telescoping into center section for empty-return shipment, reducing length to less than 10-feet.

Harco Containers can be stacked three high for conservation of storage space; provision is made for sling or fork-lift-truck handling.

Note end sections reversed for empty shipment. Seven Harco containers with their integral ground handling trailers can be shipped in the same space required for three conventional containers.



write for literature and quotations on your container and ground handling equipment requirements.
EMPLOYMENT OPPORTUNITIES FOR TRAINED MECHANICS.

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As far as shielding goes, the soft radiation poses no problem. It is the higher energy protons that will cause the trouble. About one cm of lead shielding would be sufficient to screen out particles with an energy of less than 100 mev. About four cm would be needed to reduce the energy of the higher energy protons—and some experts believe that shielding may actually be of no help at all against these particles.

Perhaps the most radical proposal for overcoming the radiation belt is Dr. Singer's "space sweeper" —a satellite that sweeps out a channel in the radiation belts by absorbing the protons that hit it as it goes through. This scheme depends on the small injection rate of the hard protons.

Theory and observations show that the polar regions may be clear of the hard radiation belt. If this is really so, interplanetary vehicles might best be launched from polar sites. One drawback is that a polar launching requires considerably more energy.

Aside from trapping radiation particles, magnetic fields are not expected to present any problems to interplanetary travel. These fields and electric currents in space are efficient on an interplanetary scale only.

Though recent data show a safe-radiation (about three-r/hr) zone between the two belts, it's generally agreed that the area between the ionosphere and an altitude of about 400 miles forms the safest zone for perfecting spaceflight techniques. We'll probably be restricted to this zone until a breakthrough is made in vehicle speed or anti-radiation methods.

Earth-moon system as a test range

Convair-Astronautics' Dr. Krafft Ehricke points out the advantages of the earth-moon system as a "test range" for interplanetary flight. Every approach to the moon must be hyperbolic, just as it would be with any other planet, so we could simulate escape and capture. On the earth we could perfect techniques for atmospheric descent and on the moon for vacuum descent. The moon itself virtually a spacecraft, could also be used for life-testing all kinds of space equipment.

more on page 104

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*3M will pay up to $300 installation charges on all first prize awards.

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F-108, NUCLEAR TURBOJET, AND RAMJET PROJECTS OFFER CHALLENGING OPPORTUNITIES TO PROFESSIONAL ENGINEERS AND SCIENTISTS

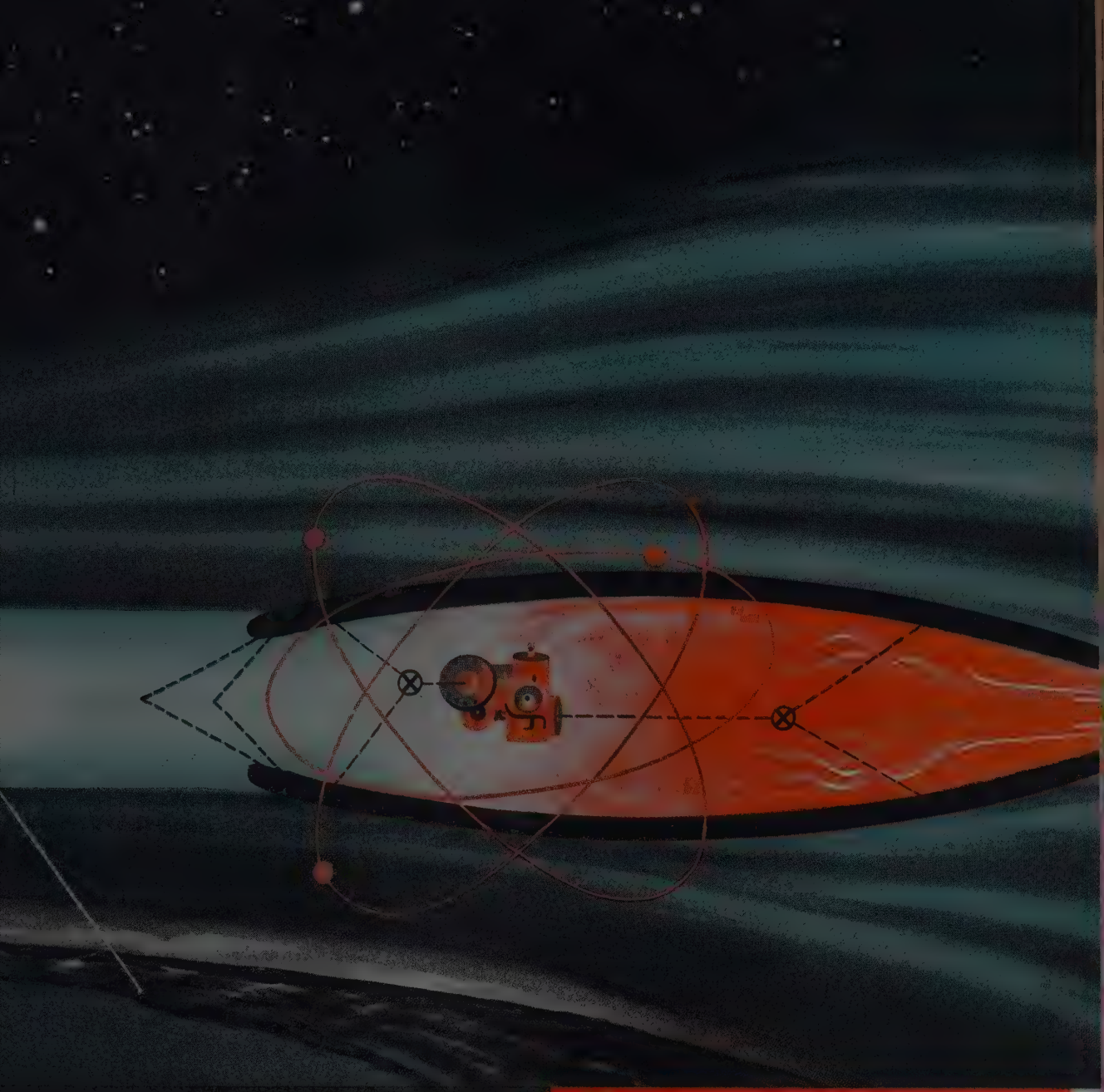
Advanced projects for air and space operations now underway in the Controls and Accessories Division at Marquardt Aircraft offer engineers and scientists challenging opportunities in a variety of technical areas. Here, where we are dealing with development problems on high-performance systems with stringent design and reliability requirements, professional engineers will find real challenge and opportunity for accomplishment.

Project personnel are currently working in such areas as the engine control system for the G-E nuclear turbojet; inlet control systems for the McDonnell F-4H, North American F-108 and the North American Hound Dog missile; the fuel control system for the supersonic Bomarc's ramjet engine; auxiliary power systems, pumps, and actuators; and are developing a unique and advanced space power unit.

C & A Division activities range in scope from preliminary design through final production.

Professional engineers and scientists capable of making contributions in these and related areas are invited to investigate the employment opportunities at Marquardt. You will find a combination of significant, active projects and a lively interest in new ideas, creating an environment for professional growth. May I suggest you write Mr. Floyd Hargiss, Professional Personnel Department, 16559 Aticoy Street, Van Nuys, California?

Roy E. Marquardt, *President*



C & A Division engineers made many contributions to the "state of the art" when they developed the fuel control system for the supersonic ramjet engine.

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probing beyond present knowledge . . . *seeking to improve the bases for tomorrow's space concepts . . . It is this exciting opportunity for serendipity that confronts the professional minds at Martin-Denver. Possibly you, too, would enjoy this stimulus for greater personal and scientific recognition. If so, we invite you to write or call N. M. Pagan, Director of Technical and Scientific Staffing, The Martin Co., P. O. Box 179, (A-2), Denver 1, Colorado.*

MARTIN
DENVER DIVISION

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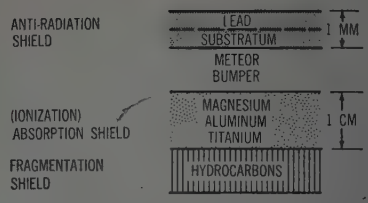

OPTIMUM radiation shield proposed by Dr. Fred Singer, U. of Maryland, is designed to withstand large flux of low energy protons. Outer skin could be spaced from inner, structural surface by a Whipple meteor bumper.

Considerable data have been obtained on acceleration effects, the second major area of our present research efforts. Air Force and Navy rocket sled and centrifuge tests show that man can withstand the G-forces of launch and deceleration. Decelerations of less than 40 G at a rate of onset below 600 G/sec and with a duration of less than 0.2 seconds can be survived with no lasting persistent injuries —if the subject is adequately restrained and facing either forward or backward in the direction of linear force.

Nothing known as yet on long zero-G effects

The effect of the zero-G phenomenon, or weightlessness, has been studied extensively in a number of Air Force programs, which are limited, of course, by the short free-fall simulation times in jet aircraft. Weightless periods of up to 45 seconds do not, generally speaking, disable either animals or human beings. Some subjects felt physical discomfort such as nausea —but with no lasting effects. However, because so little is known of the factors involved even in short-term weightlessness and virtually nothing about the intermediate sub-G state, most scientists are extremely reluctant to make extrapolations and predictions for periods of from several minutes to several hours.

The first vehicles to test manned re-entry will be capsules such as the one being developed by McDonnell for NASA's Project Mercury. It calls for a cone-shaped structure of about 2000 lb that forms the payload of a ballistic missile (Atlas or Titan). It will orbit at 120 miles

more on page 106

15 PUROLATOR FILTERS FLY WITH EVERY BOEING 707

Effective filtration is essential on the 707 just as it has been on all aircraft for the past 25 years. Fifteen Purolator Micronic filters ensure that fluids move freely, and give optimum performance, by filtering out sub-micronic particles of foreign matter . . . particles that could cause serious trouble in a jet transport going 600 miles an hour.

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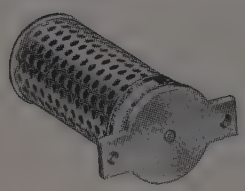

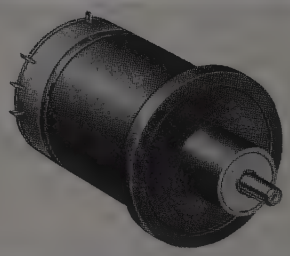

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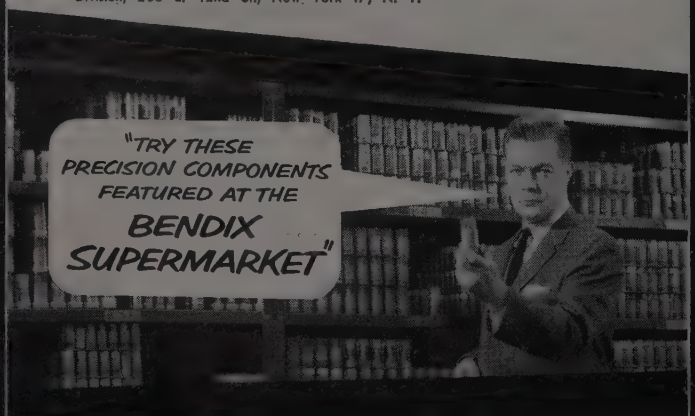

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altitude and re-enter after several passes.

The main purpose of the capsule is to test extended weightlessness. Extensive research and hardware experience on prototype recovery nose cones—particularly at GE—has provided us with enough technological know-how so that we can expect successful flights within 18 months.

Space crews to work in "shirt sleeves"

It is a foregone conclusion that a sealed cabin will be standard for space vehicles. As a backup, there will be a pressurized suit for the pilot. However, there is a good deal of support behind the idea of making the sealed compartment so reliable that the crew may forego bulky special suits and function freely in "shirt sleeves."

One of the major hazards facing all space voyagers is the loss of cabin pressure. Perhaps the greatest decompression threat is the general loss of hermetic sealing because of such factors as improper welding of structures and leaky seals around doors. Slow, rather than explosive, decompressions are expected, which would make hypoxia the main threat.

Collision with meteorites is seen as most likely to cause depression. With the cabin pressure at the ideal sea level figure of 14.7 psi a 0.005-sq in. puncture from a meteorite will leak at about 0.003 pps—exhausting the 120-day oxygen supply for one man in a single day.

Most experts believe hermetic sealing of space cabins will pose no insurmountable problems. Nevertheless, means will have to be provided to monitor leakage and calculate its rates.

Over short periods, gas exchange, food supply, and waste disposal can be handled by expendable stores and jettisoning techniques. For long periods, however, a regenerative, or closed ecological, system is a must.

Biological recycling of animal and plant byproducts has been shown to be feasible. However, we are far from a completely satisfactory model of a closed system for long space voyages. (The ideal of feeding the space traveler algae for 150 days in a row, for instance, would seem to be stretching human tolerance a bit too far.) Actually despite rapid progress our

present technology is only a very crude operational system.

Much attention has been given to unicellular algae as the principal food exchange plant for space. The plant is simple and easily controlled (though it's not clear yet whether it should be grown in solar or artificial light).

The problem of internal temperature regulation has many facets. Body heat, the clothing factor, and zero-G effects on heat removal methods must be considered. Sealed cabin air temperature should, it's felt, be kept below 113 deg F, the skin's pain threshold.

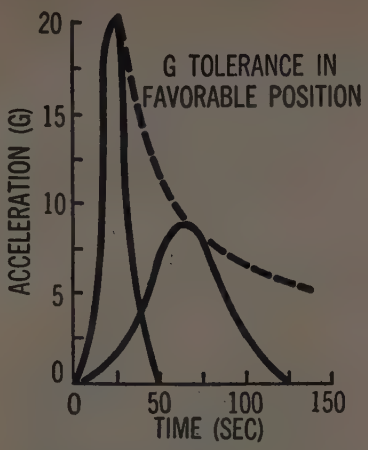
For cabin conditioning, the Navy appears to favor one atmosphere, while the Air Force generally proposes to use less than that. We have a long way to go before we have an adequate understanding of this area.

There is considerable support for the idea that nitrogen makes a better internal medium than air or helium for long space trips. Helium is a notorious leak finder and can go through fissures too small for oxygen or nitrogen. Though helium may provide most efficient internal atmospheres in the long run, it looks as though we'll be staying with nitrogen for the foreseeable future.

The psychological problems of space flight are legion, and we know next to nothing about them, with the possible exception of the area of sensory and perceptual phenomena. One reason why we have some data in this area is that a number of electronic instrument manufacturers have traditionally concerned themselves with such factors as minimum detectable stimuli in the development of indicators and displays.

In the area of decision-making—which involves learning, or adapting to entirely new stimuli, we draw almost a complete blank. Yet most people in the field concede that a learning process will be necessary if man is to succeed in interpreting sensory data under zero-G conditions.

The stresses of confinement in a sealed cockpit in the middle of nowhere are virtually unknown. Lab studies of subjects in closed rooms cannot simulate the true space environment—there's always a "panic" button within reach, and the occupant knows it's all make-believe. But even this type of experimentation has uncovered that men vary as puzzlingly in their



FOR high G-fields of as much as one minute's duration, 10-12 G can be considered the practical limit of a properly oriented and supported man's tolerance, says GE.

abnormalities under stress as in everything else.

Human factors specialists generally think that, if you have a man aboard a spacecraft, you might as well use his capabilities to eliminate as much mechanics as possible. (System engineers would rather have him asleep and fed intravenously.) In the running battle between man and machine, points are being scored on both sides, and there's no reason to believe that the balance will change very soon. Human beings still best mechanical devices in three critical areas:

- visual identification of objects of information under a wide variety of background and noise conditions.
- extremely long storage of information-action networks,
- performance of motor tasks in response to visual and other feed-back information.

Man as integral part of control loop

A commonly held conviction is that man may serve best as an integral part of the control loop and should be treated as a functional component of the control system. His function would be to take over from the automatic control system whenever some unexpected control decision, such as a landing, comes

more on next page

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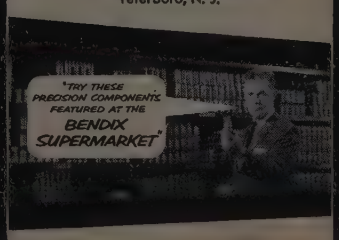

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up. (Navigation is one function that's better left to the automatic system.)

Man's progress through space surely will be marked by a number of unavoidable and yet unpredictable emergencies and accidents. To raise the odds on survival, we'll have to evolve a versatile and fail-safe escape system aboard the vehicle and effective techniques for rescue from the outside. Douglas' Dr. Alfred Mayo sums up current thinking by suggesting an escape system that uses the smallest possible portion of the overall space vehicle for mechanisms for ground and atmospheric escape. In addition, it would be possible to jettison dangerous or malfunctioning parts, or the inhabited section itself.—End

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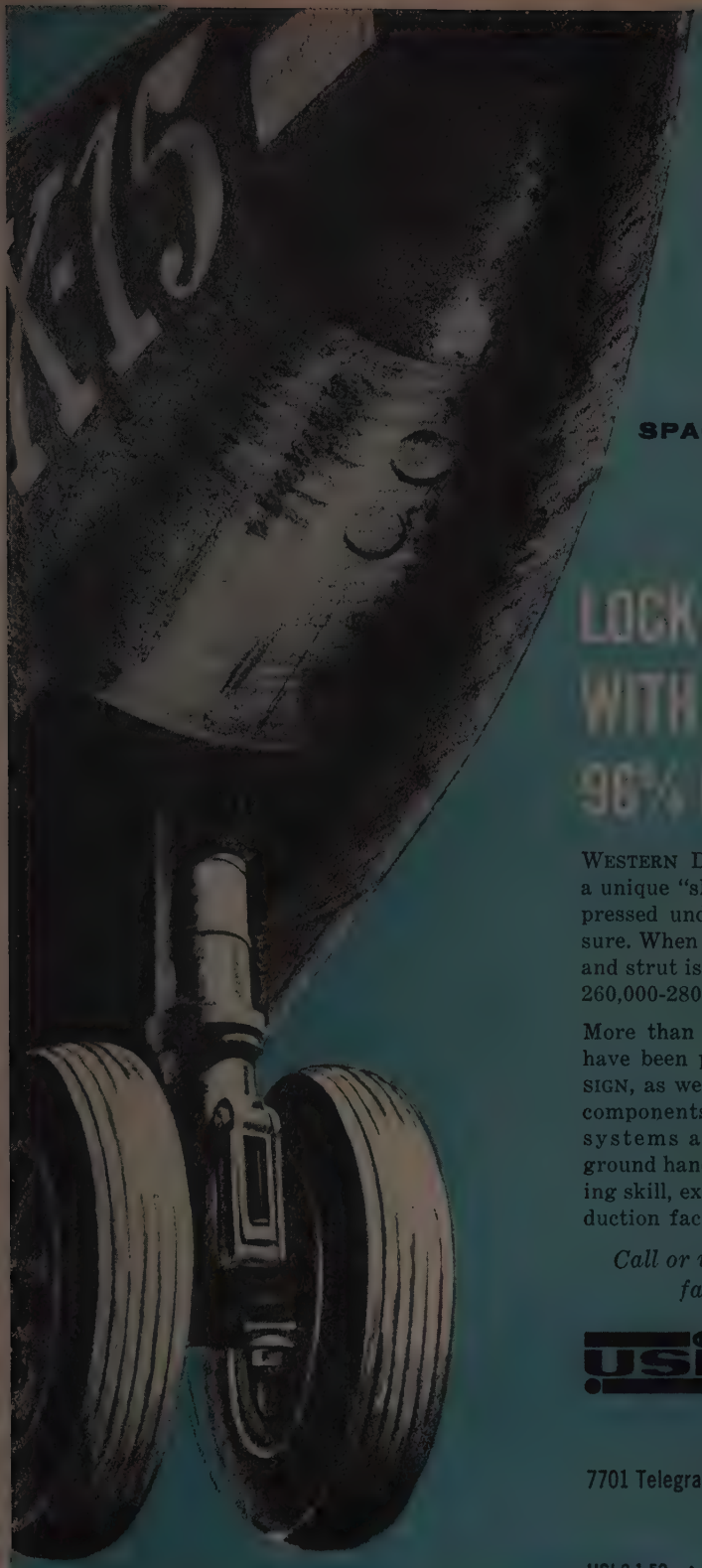

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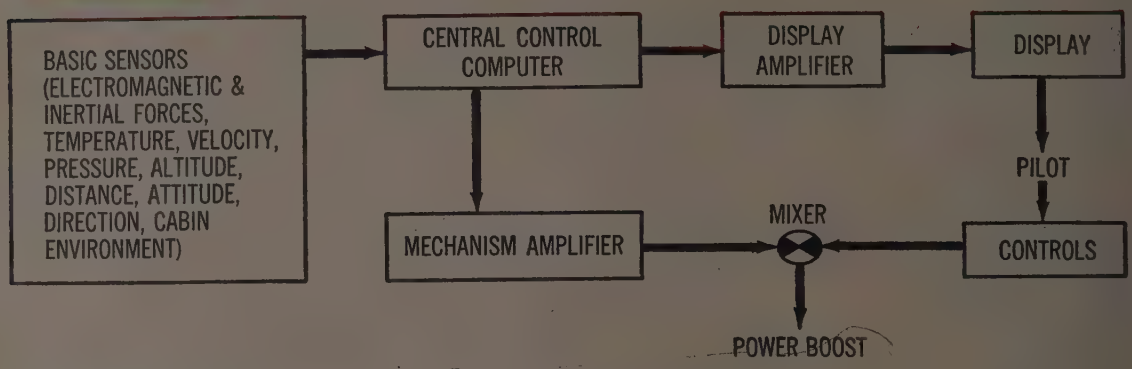

BASIC man-machine relationship for integral spacecraft instrument display.

What instruments for space crews?

Space instrumentation will have to work within an entirely new kind of reference system—without a horizon, with a constantly changing "up", and so on. Yet it should not pose an insuperable design task, provided it is tackled in time and fully integrated into the overall vehicle.

by George W. Hoover, Director of Technical Planning, Benson-Lehner Corp.*

IN SPACE there can be no forced landings or aborted flights. We must therefore make sure that our space instrumentation systems will meet every requirement of the pilot, be completely reliable, and require a minimum of mental integration.

The space pilot essentially will need the same information about his craft's orientation and direction as he would in an aircraft. For his basic problem is the same, too—how to get from one point A to another. The big difference is in the sensors used. The fact that in space we must deal with a completely new reference system will show up primarily in the sensors we will have to use.

"Up", for instance, will not necessarily be on a radial from the center of the earth. It would be more reasonable to measure the vertical perpendicular to the plane of trajectory. But since this plane will be curved (because of the movement of the earth and of the body of destination—be it a space station, the moon, or a planet), the vertical will be continuously changing.

A gyro could be used as the vertical sensor if it is precessed at a given rate. An even better solution might be a star tracker with which the vertical with respect to a precomputed trajectory could be determined on a time basis.

It would be possible to calculate a family of trajectories from the launch site on earth to the destination (which might be anything from another planet to just an orbit about the earth). With this family of trajectories plotted with respect to star positions, for given times, and corrected for changing altitude above the earth, a vertical to the plane of the trajectory could be computed and maintained by a star tracker and a computer.

The continuously changing vertical could be used to provide the pilot with a display for basic orientation. It could also be used to calculate the direction of the plane of trajectory for directional information.

The pilot should not need a three-dimensional plot of position, since a situation display with respect to the curved plane of trajectory is in itself two-dimensional. The situation display could then be

more on page 112

*Benson-Lehner Corp., 11930 W. Olympic Blvd., Los Angeles 64, Calif.

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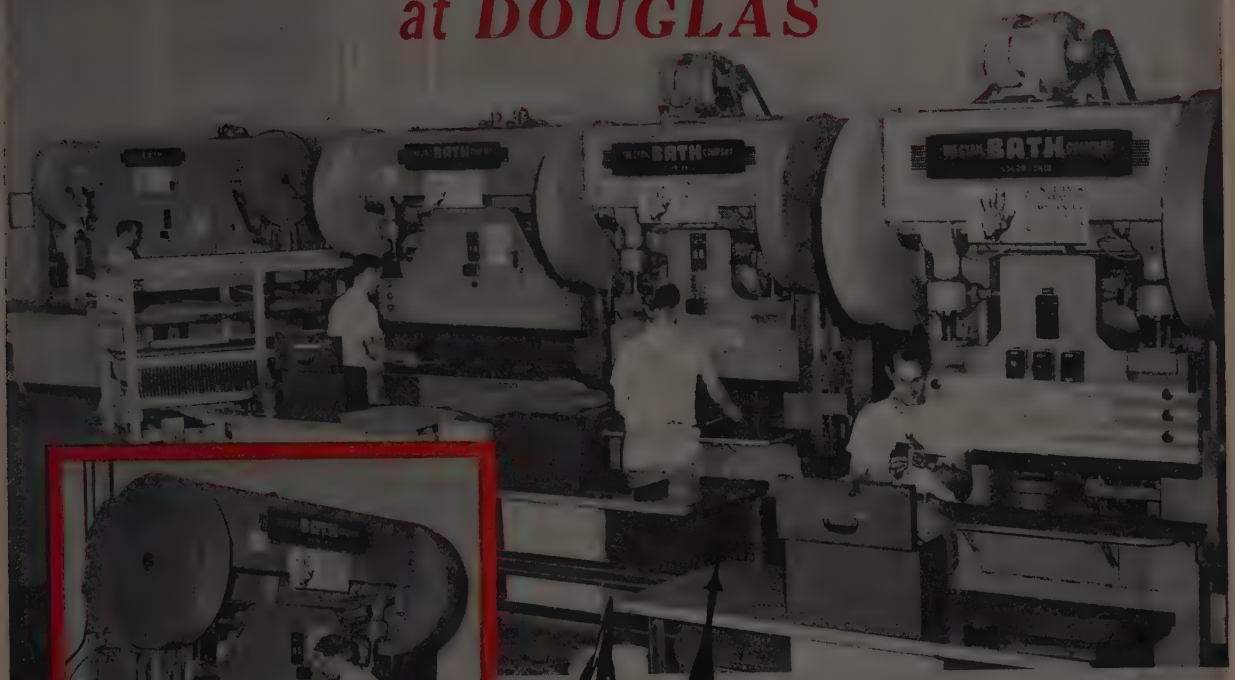

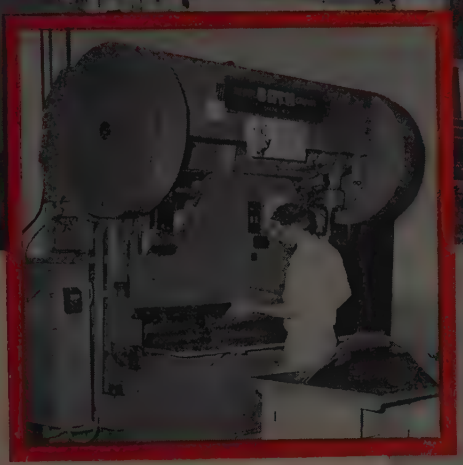

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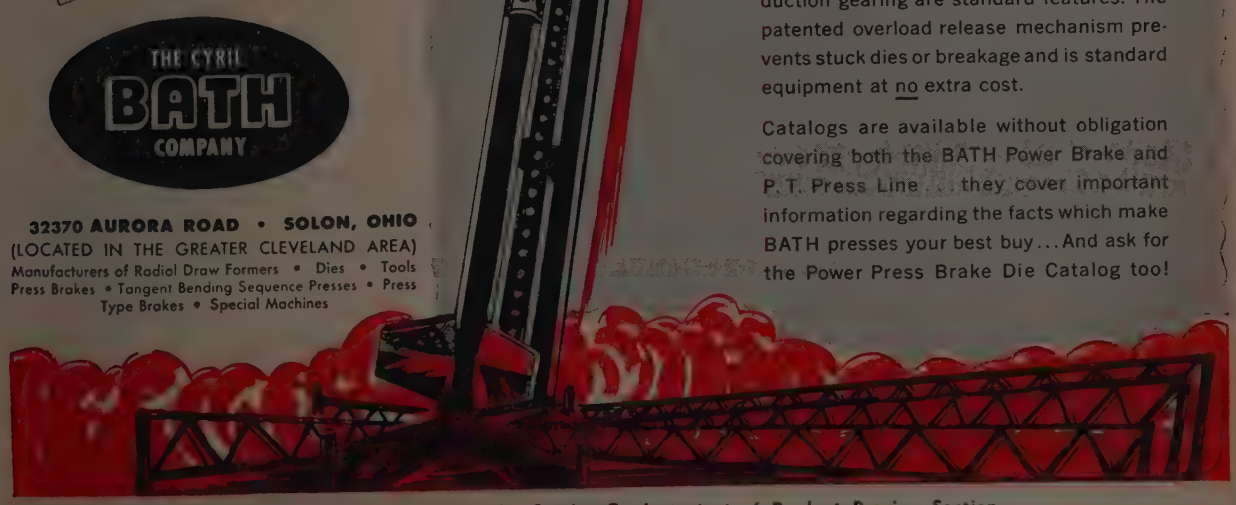

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the ship's location relative to ends of the plane of trajectory.

In solving the position of the ship relative to the stars and relating this to a family of stored trajectories, system operation becomes analogous to that of an automatic, continuously changing three-dimensional Loran system in which the transmitters are replaced by stars. The biggest development problem would be the creation of a three-dimensional ephemeris for storage in the computer memory.

Such a system of sensing could provide the information needed for both orientation and direction outside the atmosphere. Within the atmosphere, the situation is complicated by the problem of increasing air density.

The optimum path now must not only be in the direction of the destination but also provide a vertical displacement that changes as a function of the rate of heat dissipation. In other words, the pilot must be given display that will keep him from re-entering the atmosphere in such a way that his craft absorbs more of a temperature rise than it can dissipate or tolerate.

Rate of density change as attitude reference

The pilot's attitude (as a function of orientation) cannot be referenced to a vertical about the pitch axis but must be referenced to a rate of change of density. A temperature sensor, for example, might supply the computer with a rate of change in temperature that could be converted to a change in the pitch angle of the director path display.

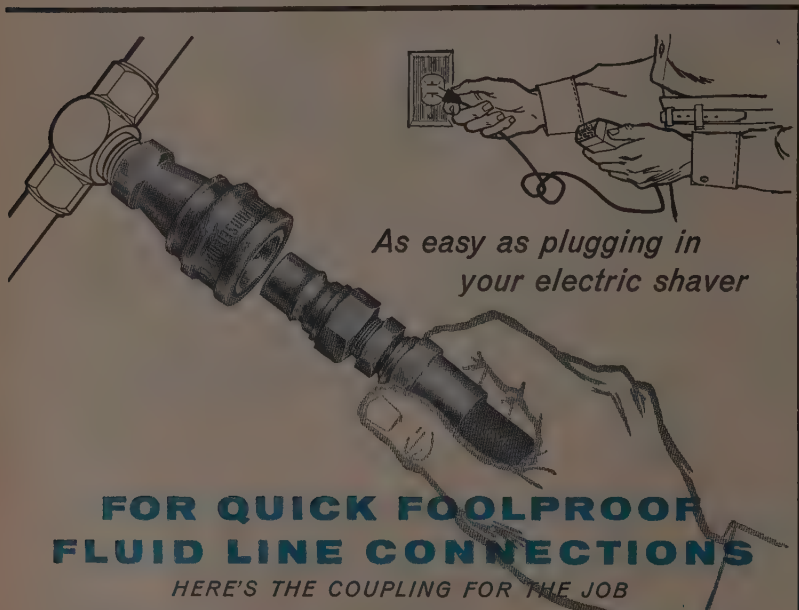
When the velocity of the ship has reached a level at which temperature is no longer a problem, a conventional vertical sensor (or star tracker) could once again provide the horizon reference. From that point on, the ship would be flying very much as a conventional aircraft.

All these suggestions, of course, do not necessarily give the best solutions. In any case, though, it is important that the pilot be given a display similar to the one he uses for orientation on earth.

System sensors for the entire space flight profile must be designed to the *crew's* information needs. In the case of radiation, for example, the crew's major concern is how much and what type of radiation is penetrating the hull, and not the external radiation. Again, it is not so important to count the number of meteorite hits as it is to determine the amount of damage they do and the loss of pressure caused by leaks.

By the same token, the numerical values of velocity, pressure, altitude, and distance mean very little to the space pilot. He is much more concerned with whether or not the ratio of actual and desired quantities is within limits and if the rate of deviation is tolerable.

When you come right down to it, the problems of instrumentation are no greater or more complex for space ships than for any other vehicle. They can be solved if the crew's information needs are thought out beforehand for each phase of the whole flight.—End



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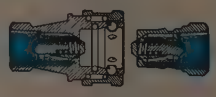

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Another important advance in man's knowledge of outer space was provided by Pioneer III. This, like many others of a continuing series of space probes, was designed and launched by Jet Propulsion Laboratory for the National Aeronautics and Space Administration. JPL is administered by the California Institute of Technology for NASA.

During its flight of 38 hours, Pioneer III was tracked by JPL tracking stations for 25 hours, the maximum time it was above the horizon for these stations.

The primary scientific experiment was the measurement of the radiation environment at distances far from the Earth and telemetering data of fundamental scientific value was recorded for 22 hours. Analysis of this data revealed, at 10,000 miles from the Earth, the existence of a belt of high radiation intensity greater than that observed by the Explorer satellites.

This discovery is of vital importance as it poses new problems affecting the dispatch of future vehicles into space. The study and solution of such problems compose a large part of the research and development programs now in extensive operation at the Laboratory.

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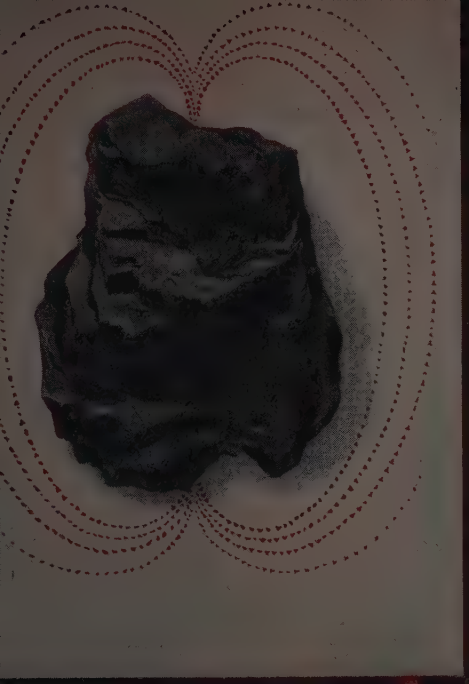

MAGNETOHYDRODYNAMICS Lockheed's 3rd Annual "Symposium" on this important new field—which deals with the behavior of conducting fluids in magnetic fields—attracted physicists from all over the world. As portrayed by the artist, man's earlier experiment with magnetic forces involved the use of the ancient lodestone. Sol's prominences are a dramatic example of such forces under investigation today.

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Biosatellite decompression

THESE NOMOGRAPHS make it possible to calculate some of the effects of decompression on the human or animal occupants of a "biosatellite." *Nomograph 1* gives the time (t) of decompression from an initial cabin pressure (P_{co}) of 14.7 psi (760 mm Hg) to any cabin equivalent altitude up to 50,000 ft. Partly because of the assumptions on which it is based, it gives approximate rather than precise solutions. For this reason, it is intended only for quick and simple comparison of a large number of decompression conditions.

Nomograph 1 is derived from the equation for the escape of air through an orifice in a biosatellite:

(1) $dW/dt = -KWAC/V144$ *pps*,

where W is the instantaneous weight of the enclosed air (in pounds); K, the orifice coefficient, which is assumed to be 1; A, the orifice area (in square inches); C, the speed of the escaping air, which equals the speed of sound; and V, the volume of the enclosed air, or of the biosatellite (in cubic feet).

By separating the variables, we get:

(2) $dW/W = -ACdt/144V$.

Assuming an isothermal change, the thermodynamic equation of state gives:

(3) $-dP_c/P_c = dW/W$,

where P_c is the instantaneous cabin pressure. We can now write *Equation 2* as:

(4) $dP_c/P_c = -ACdt/144\,V$.

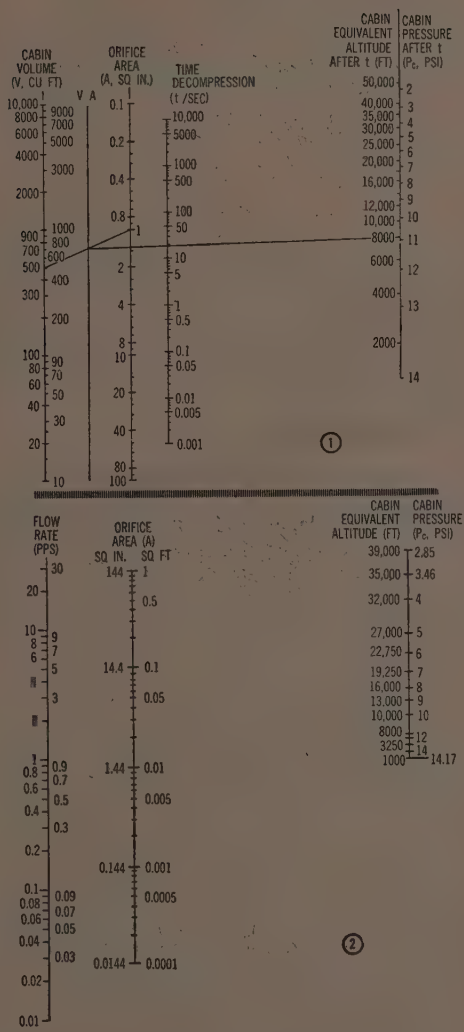
By integrating we get:

(5) $t = (144V/AC)ln(P_{co}/P_c)$, or $P_c = P_{co}\,exp(-ACt/144V)$.

Nomograph 1 solves *Equations 5* for P_{co}=14.7 psi and C=1130 fps (the speed of sound at 68 deg F).

Nomograph 2 summarizes some of the results of an IBM 701 program set up by the Douglas-Tulsa Air Conditioning and Computing Sections for computing the pressure-time relationships and flow rates of biosatellite decompression. The program was based on two assumptions:

- The cabin exhausts to an infinite volume, or a vacuum.
- The flow through the orifice is sonic. Therefore, the outside pressure (P_a) must be low enough so that the ratio P_c/P_a exceeds the critical pressure, or $(n+1)/2^{n/(n-1)}$, where n is the polytropic exponent, which varies from 1 for isothermal expansion to 1.4 for adiabatic expansion.


CABIN VOLUME (V, CU FT)
ORIFICE AREA (A, SQ IN.)
TIME DECOMPRESSION (t /SEC)
CABIN EQUIVALENT ALTITUDE AFTER t (FT)
CABIN PRESSURE AFTER t (Pc, PSI)
V A
1
FLOW RATE (PPS)
ORIFICE AREA (A) SQ IN. SQ FT
CABIN EQUIVALENT ALTITUDE (FT)
CABIN PRESSURE (Pc, PSI)
14.17

Nomograph 2, simply draw a line through P_c (in psi) and A (in square inches or feet) and extend it to the flow rate scale.

These nomographs by Eugene B. Konecci, Head, Bio-Astronautics & Human Factors Dept., Inc., El Segundo, Calif., are from a paper, "Decompression Events in Biosatellites," given at the Semi-Annual Meeting of the American Rocket Society in Los Angeles on June 8-12, 1958.

A limited number of reprints of these nomographs is available upon request from Reprint Dept., SPACE/AERONAUTICS, *205 E. 42nd St., New York 17, N.Y.*

Optimized boost system staging

THIS IS a nomograph for estimating the optimum mass ratios and payload-to-gross-weight ratios of multi-stage rocket vehicles. Derived essentially from the Malina-Summerfield optimization criterion, it assumes a constant specific impulse (I_{SP}) and burnout-to-gross-weight ratio (ϵ) per step (see *Configuration Definitions*) and neglects gravity and drag.

Graph 1 is based on:

$$\mu = e^{\Sigma\Delta V/nI_{SP}g},$$

where μ is the ratio per stage of the gross weights at the beginning and the end of the boost period and is assumed to be constant; $\Sigma\Delta V$, the summation of the incremental stage velocities, assumed to be 30,000 fps; n, the number of stages; and I_{SP} is assumed to be constant per stage. Curves of n for $\Sigma\Delta V$ values other than 30,000 fps are also given to increase the range of possible solutions.

Graph 4 is based on:

$$W_{PLn}/W_{G1} = \{(1-\mu\epsilon)/[\mu(1-\epsilon)]\}^n,$$

where W_{PLn} is the payload weight of the nth stage; W_{G1}, the gross weight of the first stage; and ϵ equals 0.1.

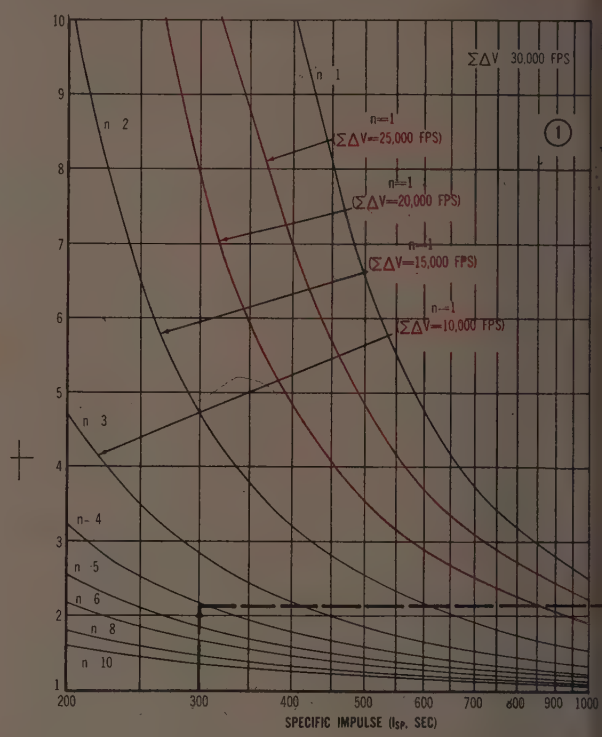
Sample Problem—A moon landing vehicle has a required $\Sigma\Delta V$ of 45,000 fps. Available I_{SP} is 300 sec per stage; available ϵ, 0.12 per stage; and net payload, 1000 lb.

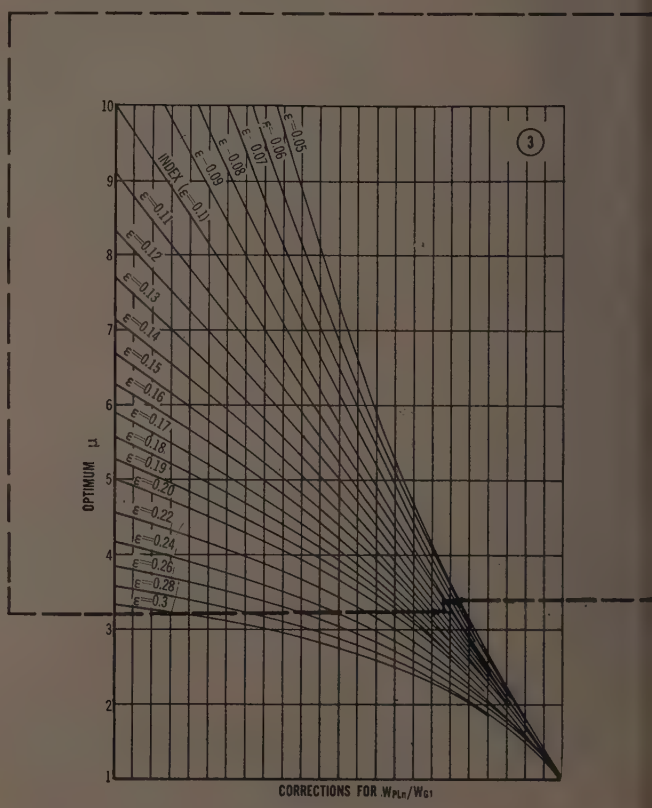
Assuming this vehicle had four stages, begin by finding I_{SP}=300 for n=4 in *Graph 1*. Then move right to $\Sigma\Delta V$=45,000 and vertically to the index in *Graph 2*. From there move horizontally to *Graph 3* and read the optimum μ per stage of 3.2. Now move right to ϵ=0.12 and vertically to the index. Finally move right to *Graph 4* to n=4. After moving straight down, read W_{PLn}/W_{G1}=0.0024.

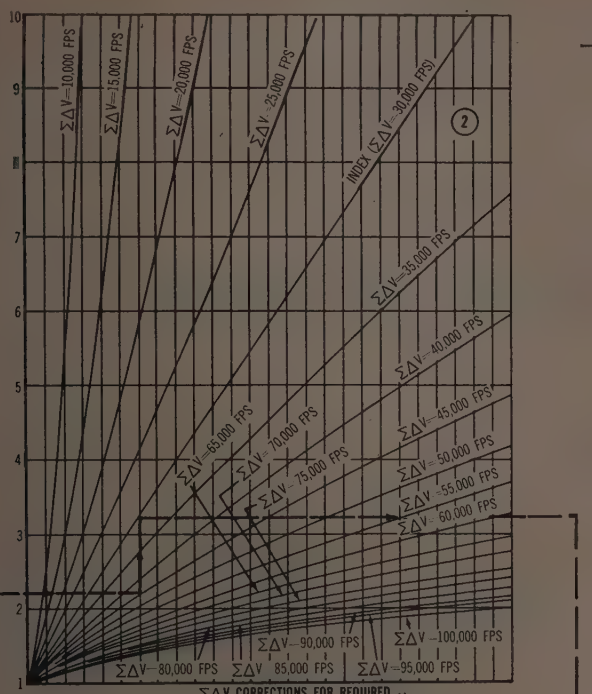
You can now calculate that, to land 1000 lb of net payload on the moon, the takeoff weight of the optimum four-stage vehicle must be about 417,000 lb.

This nomograph was prepared for SPACE/AERONAUTICS *by R. C. Kolyer, Dynamics Branch, and C. E. Vandenberg, Aero/Space Laboratories, Missile Div., North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.*

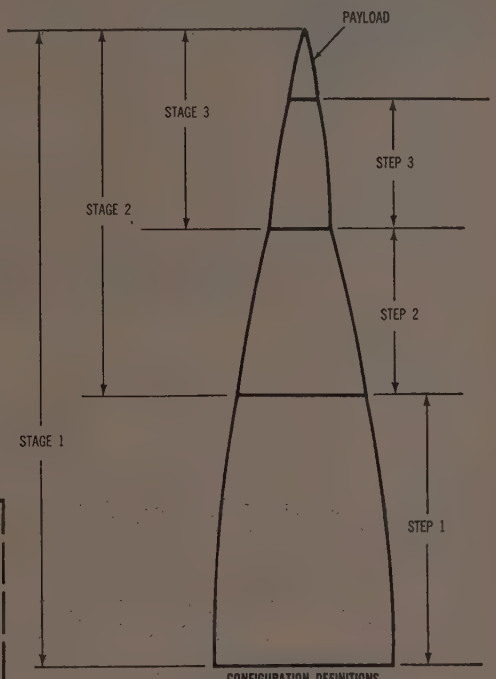
A limited number of reprints of this nomograph is available upon request from Reprint Dept., SPACE/AERONAUTICS, *205 E. 42nd St., New York 17, N.Y.*



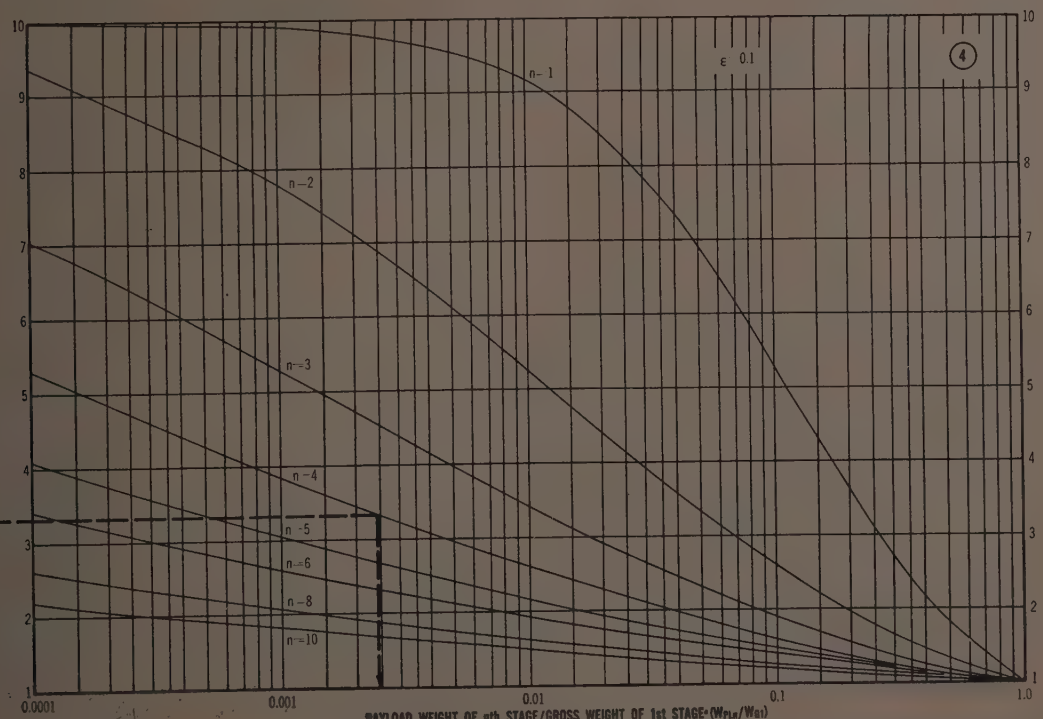




ΣΔV CORRECTIONS FOR REQUIRED μ

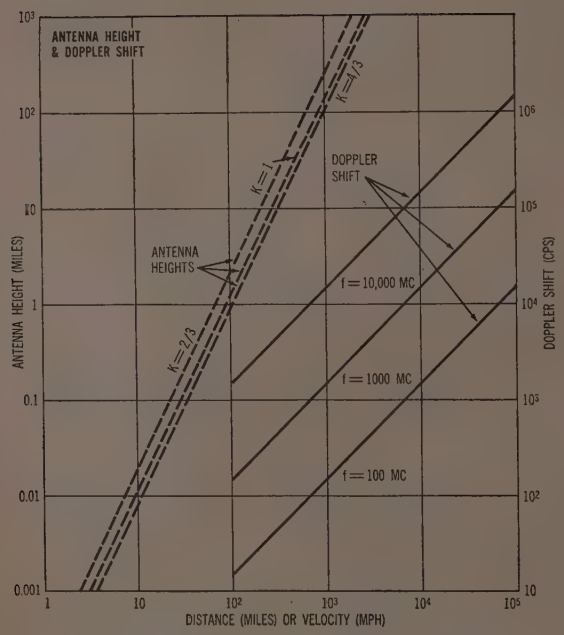


CONFIGURATION DEFINITIONS



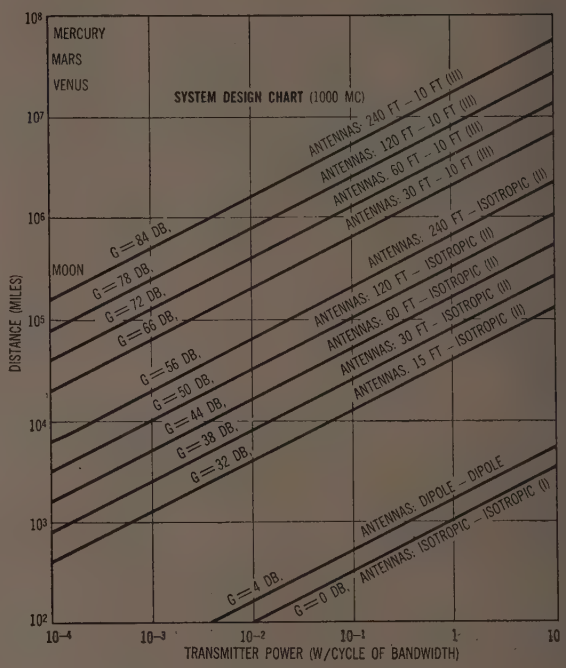
PAYLOAD WEIGHT OF nth STAGE/GROSS WEIGHT OF 1st STAGE=(W_{PLn}/W_{G1})

Space communications



Antenna Height and Doppler Shift

Notes: (1) K, or effective earth radius factor, gives the slight curving effect of the refraction caused by the presence of the earth's surface and atmosphere on the direct path of simple line-of-sight transmission. So long as the change in refractive index is linear with height, the net effect of refraction is the same as if the radio waves continued to travel in a straight line but over an earth with a modified radius equaling the true radius times K. For U.S. standard atmosphere, K equals 4/3. **(2)** The maximum value of Doppler shift can be written as $f_s = fv/c$, where f is carrier frequency, v is relative velocity between transmitter and receiver, and c is the speed of light.


MERCURY
MARS
VENUS
SYSTEM DESIGN CHART (1000 MC)
ANTENNAS: 240 FT – 10 FT (III)
ANTENNAS: 120 FT – 10 FT (III)
ANTENNAS: 60 FT – 10 FT (III)
ANTENNAS: 30 FT – 10 FT (III)
ANTENNAS: 240 FT – ISOTROPIC (II)
ANTENNAS: 120 FT – ISOTROPIC (II)
ANTENNAS: 60 FT – ISOTROPIC (II)
ANTENNAS: 30 FT – ISOTROPIC (II)
ANTENNAS: 15 FT – ISOTROPIC (II)
MOON
G = 84 DB.
G = 78 DB.
G = 72 DB.
G = 66 DB.
G = 56 DB.
G = 50 DB.
G = 44 DB.
G = 38 DB.
G = 32 DB.
ANTENNAS: DIPOLE – DIPOLE
ANTENNAS: ISOTROPIC – ISOTROPIC (I)
G = 4 DB.
G = 0 DB.
DISTANCE (MILES)
TRANSMITTER POWER (W/CYCLE OF BANDWIDTH)

System Design Chart (1000 mc)

Note: Curves are for a carrier-noise power ratio of 15 db, a receiver noise figure of eight decibels, a fading allowance of 20 db, and parabolic antennas, where G is antenna system gain. For isotropic-isotropic (Group I) and directive-directive (Group III) antenna systems, correction factors must be used for frequencies (f, in megacycles) other than 1000 mc: Group I—distance, 1000/f; power, f/1000; Group III—distance, $(f/1000)^2$; power, $(1000/f)^2$. No correction is needed for Group II. Optimum frequencies can be found from the graph of system parameters vs frequency as—Group I: 40-100 mc for one-way communications; Group II: 100-300 mc for one-way communications; Group III: 2000-4000 mc for one-way communications or radar and for two-way passive relay or radar.

The graph of space loss and time lag was prepared for **Space/Aeronautics** by F. W. Lehan, Space Electronics Corp., 1200 Air Way, Glendale 1, Calif. The other graphs and the table are from a paper, "Introduction to Space Communication Design," presented at the Fourth National Aero-Com Symposium (IRE) in Utica, N.Y., last Oct. 20-21, by Leang P. Yeh, Fellow Engineer, Westinghouse Electric Corp., P. O. Box 746, Baltimore 3, Md.

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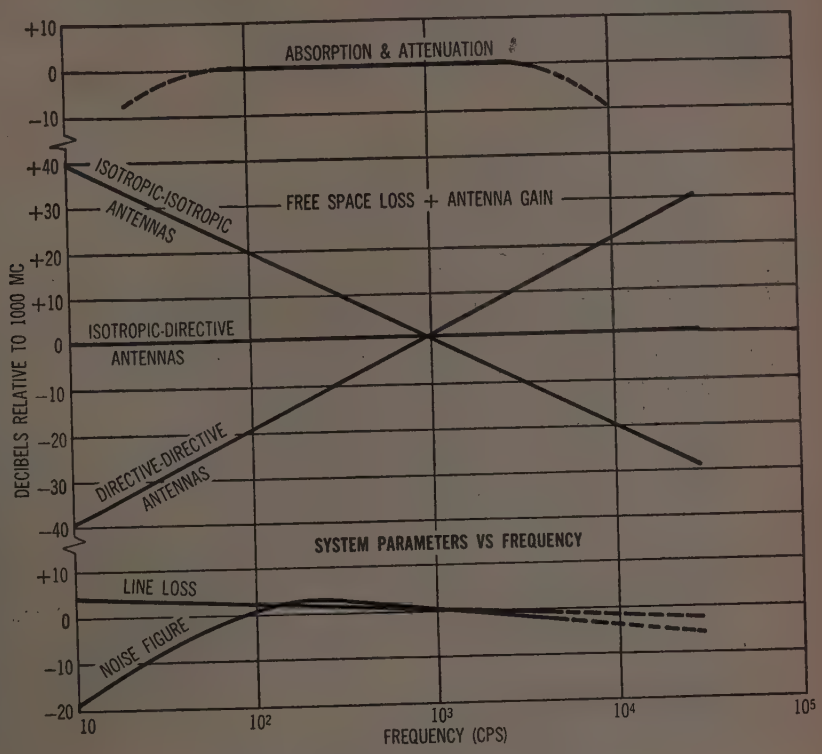


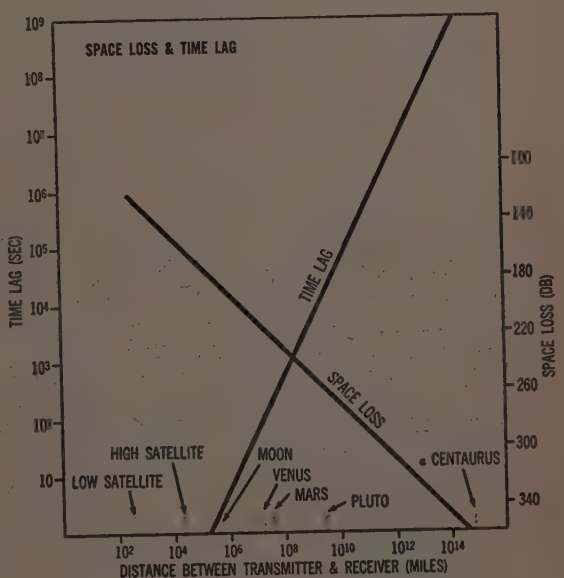
System Parameters vs Frequency

Note: At 1000 mc, line loss is —3 db and noise figure is —8 db.

Feasible Direct Communication Ranges*

Bandwidth	Range (miles)	
	Space-to-Space	Space-to-Earth or Earth-to-Space
1 cps	30,000	2,000,000
10 cps	10,000	700,000
100 cps	3,000	200,000
1 kc	1,000	70,000
10 kc	300	20,000
100 kc	100	7000
1 mc	30	2,000

*Based on the 100-mc system design chart at left and assuming the following system characteristics: transmitter power, 10 W; space antenna, isotropic; earth antenna aperture, 240 ft; fading margin, 20 db; carrier-noise power ratio, 15 db; frequency, 100 mc (space-to-space) and 300 mc (space-to-earth or earth-to-space), respectively. For space-to-space systems, the frequency correction factor is 10. Range varies inversely with the halfth power of the bandwidth.



Space Loss and Time Lag

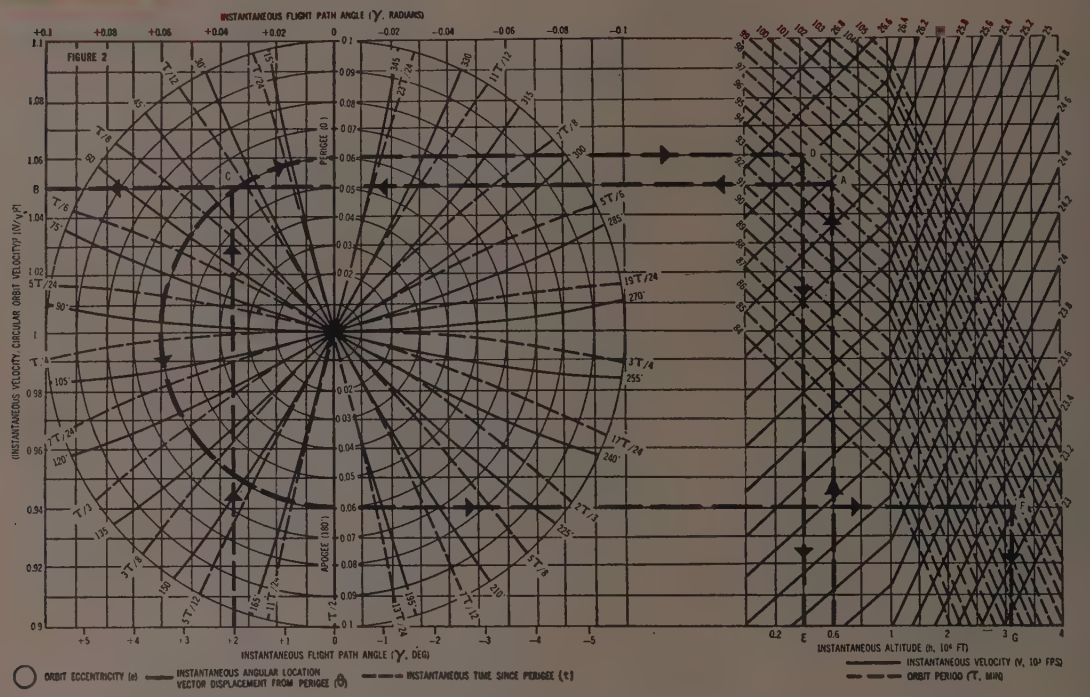


FIGURE 2
INSTANTANEOUS FLIGHT PATH ANGLE (γ, RADIANS)
INSTANTANEOUS VELOCITY: CIRCULAR ORBIT VELOCITY (V/V_c)
INSTANTANEOUS FLIGHT PATH ANGLE (γ, DEG)
INSTANTANEOUS ALTITUDE (h, 10⁴ FT)
INSTANTANEOUS VELOCITY (V, 10³ FPS)
ORBIT PERIOD (T, MIN)
ORBIT ECCENTRICITY (e)
INSTANTANEOUS ANGULAR LOCATION VECTOR DISPLACEMENT FROM PERIGEE (θ)
INSTANTANEOUS TIME SINCE PERIGEE (t)
PERIGEE (0)
APOGEE (180°)

Orbit Relationships

THIS nomograph of the orbit relationships for a mass point in a central force field is intended for use in comparative analyses and preliminary studies. It cannot be used for any highly accurate determination of orbit characteristics.

The nomograph is confined to orbits of comparatively small eccentricities, since these allow us to make certain simplifying assumptions in obtaining the equations for the nomograph's various curves. Aerodynamic forces are neglected, and the earth is assumed to be a non-rotating sphere.

With these points in mind, we can define all the characteristics of any orbit in terms of seven variables (*Fig. 1*):

- instantaneous velocity with respect to the earth (V, in fps),
- instantaneous altitude above the earth's surface (h, in feet),
- orbit eccentricity (e),

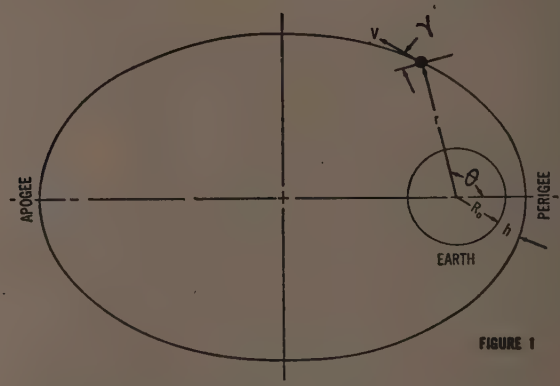


FIGURE 1

- instantaneous flight path angle (γ, in radians or degrees),
- orbit period (τ, in seconds or minutes),
- instantaneous time since perigee (t, in seconds or minutes) which equals $\tau\phi/2\pi$.
- instantaneous angular location vector displacement from perigee (θ, in radians or degrees).

more on page 126

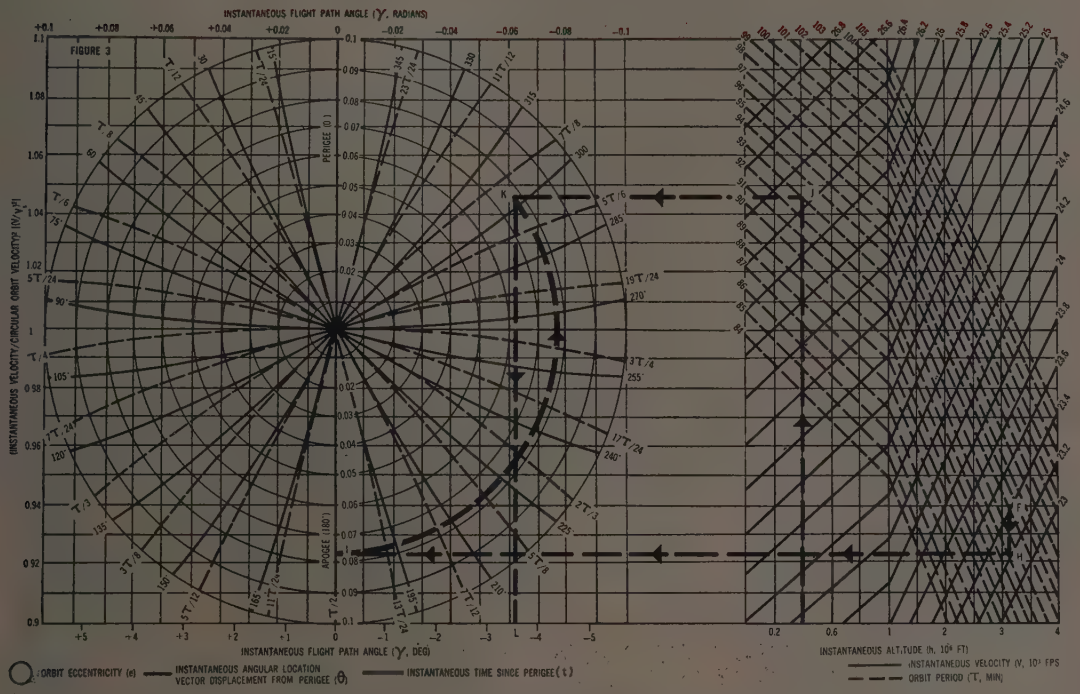


FIGURE 3
INSTANTANEOUS FLIGHT PATH ANGLE (γ, RADIANS)
INSTANTANEOUS VELOCITY/CIRCULAR ORBIT VELOCITY (V/V_c)
PERIGEE (0°)
APOGEE (180°)
INSTANTANEOUS FLIGHT PATH ANGLE (γ, DEG)
INSTANTANEOUS ALTITUDE (h, 10⁴ FT)
INSTANTANEOUS VELOCITY (V, 10³ FPS)
ORBIT PERIOD (T, MIN)
ORBIT ECCENTRICITY (e)
INSTANTANEOUS ANGULAR LOCATION VECTOR DISPLACEMENT FROM PERIGEE (θ)
INSTANTANEOUS TIME SINCE PERIGEE (t)

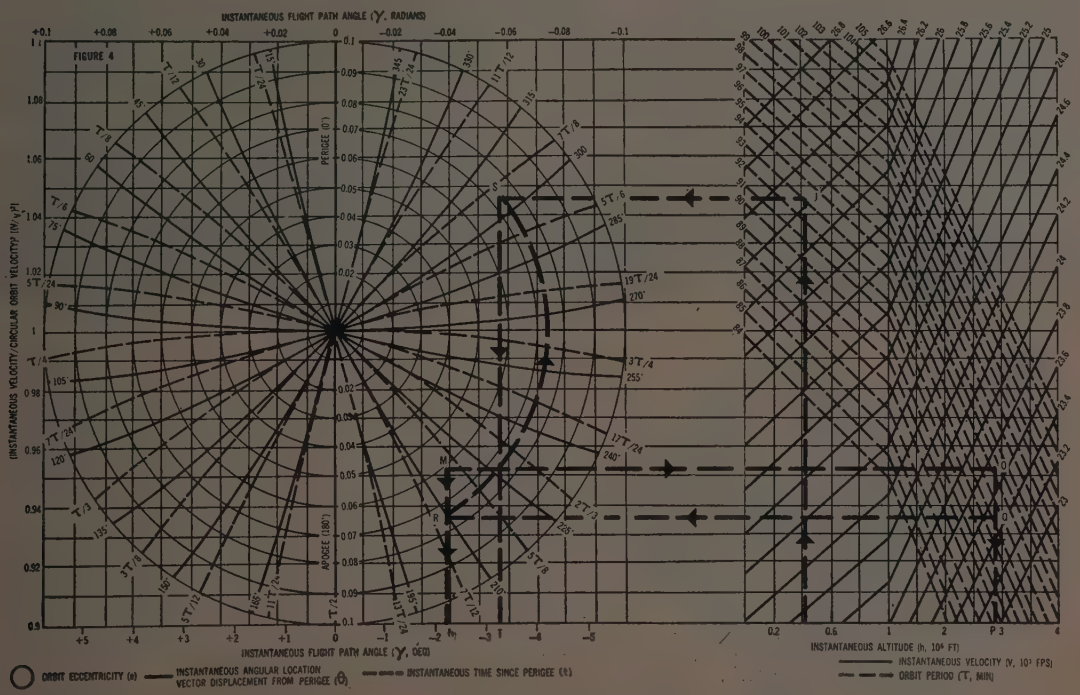


FIGURE 4
INSTANTANEOUS FLIGHT PATH ANGLE (γ, RADIANS)
INSTANTANEOUS VELOCITY/CIRCULAR ORBIT VELOCITY (V/V_c)
PERIGEE (0°)
APOGEE (180°)
INSTANTANEOUS FLIGHT PATH ANGLE (γ, DEG)
INSTANTANEOUS ALTITUDE (h, 10⁴ FT)
INSTANTANEOUS VELOCITY (V, 10³ FPS)
ORBIT PERIOD (T, MIN)
ORBIT ECCENTRICITY (e)
INSTANTANEOUS ANGULAR LOCATION VECTOR DISPLACEMENT FROM PERIGEE (θ)
INSTANTANEOUS TIME SINCE PERIGEE (t)

After 8 years of research North American introduces a low-cost Space Age material:

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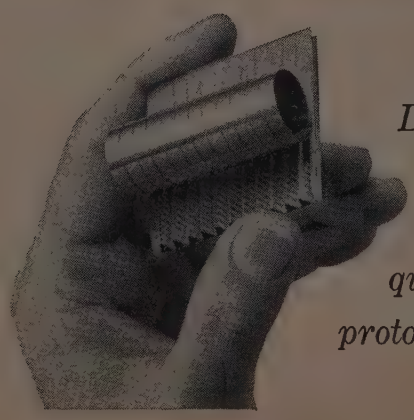

Designers may now obtain experimental quantities for prototype development

WHAT IT IS: SPACEMETAL is a stainless steel sandwich with the light weight high strength, and heat resistance required for Space Age missiles and planes. Inner sheet is beaded to form a V-shaped corrugation which allows rapid heat dissipation, permits hydrostatic testing for quality control. Yield weight savings (theoretical) as high as 75 percent over solid materials.

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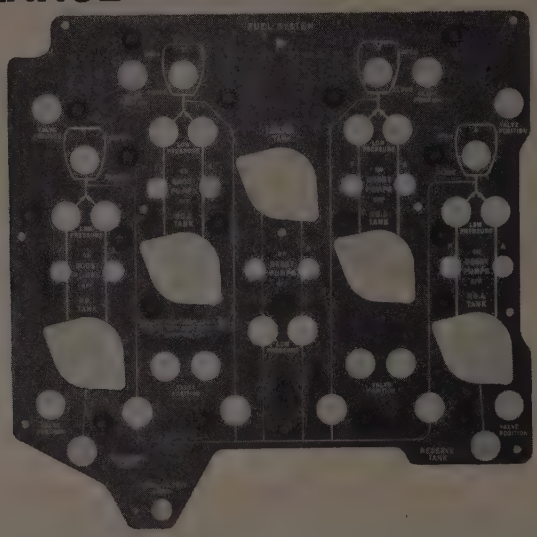
HOW TO GET IT: SPACEMETAL is available in experimental quantities to designers seeking its unique properties for application in missiles, supersonic aircraft, and related projects. Please write for complete information, outlining your requirements, to: SPACEMETAL, Dept. 496 B, Missile Division, North American Aviation, Inc., 12215 Lakewood Blvd., Downey, Calif.

THE MISSILE DIVISION OF NORTH AMERICAN AVIATION, INC.

in the Boeing 707...

NEW INSTRUMENT PANEL GIVES ACCURATE FUEL DATA AT A GLANCE



Pilots of Boeing's 707 jet liners rely on new USR-engineered fuel system panels for quick, clear, concise information. The ready legibility inherent in the design of these integral edge-lighted panels makes it comparatively simple for the pilot to keep track of fuel load levels in jet flight where fuel management and control are always-critical factors.

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ORBIT RELATIONSHIPS

Defining Equations

Exact Equations

$$V = \left[\frac{g_o R_o^2}{R_o + h}\left(\frac{V}{V_s}\right)^2\right]^{1/2}$$

$$\tau = \left\{\frac{R_o + h}{\left(\frac{g_o R_o^2}{4\pi^2}\right)^{1/3}\left[2 - \left(\frac{V}{V_s}\right)^2\right]}\right\}^{3/2}$$

Approximate Equations

$$e = \left\{\gamma^2 + \left[1 - \left(\frac{V}{V_s}\right)^2\right]^2\right\}^{1/2} \leqq 0.1$$

for $\gamma \leqq 0.1$ rad

$$\phi = \tan^{-1}\left[\frac{\gamma}{1 - \left(\frac{V}{V_s}\right)^2}\right] - \gamma$$

for $e \leqq 0.1$, $\gamma \leqq 0.1$ rad

$$\theta = \tan^{-1}\left[\frac{\gamma}{1 - \left(\frac{V}{V_s}\right)^2}\right] + \gamma$$

for $e \leqq 0.1$, $\gamma \leqq 0.1$ rad

The square of the ratio of V to the circular orbit velocity (V_S) is the common ordinate of the entire nomograph. The abscissas are h for the right part of the nomograph and γ for the left part. (The h-scale is reduced for values above 10^6 ft, so that larger apogee values can be accommodated while the order of accuracy of the perigee values is retained.)

The *Table* gives the defining equations for the remaining variables.

Sample Problem—Determine the orbit characteristics of a satellite for which the following burnout values apply: h=600,000 ft, V=26,200 fps, and γ=2 deg.

Enter *Figure 2* at h=600,000 and move up vertically till you intersect the V=26,000 curve at *Point A*. Read τ=95 minutes.

Move horizontally to *Point B* on the $(V/V_S)^2$-scale and read 1.05. This gives V_s=25,600 fps.

Enter again at γ=2 deg and move up till you intersect line *A-B* at *Point C*. Read e=0.06, θ=36 deg, and $t=\tau/11.6$, which gives t=95/11.6=8.19 minutes.

Move along the constant e-curve to the perigee and then horizontally to the right to *Point D* on the previous energy line (constant τ) established by *Point A*. Read $V_{p(erigee)}$=26,440 fps.

Move down vertically to *Point E* on the h-scale and read h_P=400,000 ft.

Return to *Point C* and move

more on page 129

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along the *e*-curve to the apogee line and then right to *Point F* on the τ-curve established by *Point A*. Read $V_{a(apogee)}$=23,430 ft.

Move down to *Point G* on the *h*-scale and read h_a=3,100,000 ft.

Now determine the re-entry conditions at 400,000 ft brought about by a retro-thrust equivalent to $\Delta V = -200$ fps and applied at the apogee of the orbit established in *Figure 2*.

Establish *Point F* (V_a—23,430 fps) in *Figure 3*. Move down to *Point H* on the new V_a-curve of 23,400—200, or 23,200 fps. Read τ_{new}=93 minutes.

Move left to *Point I* on the apogee line and read e_{new}=0.077 and $t = \tau/2$. Now calculate the time from burnout to apogee as part of the period of the initial orbit, which has of course been followed: $\Delta t = t_a - t_{bo} = (\frac{1}{2} - 1/11.6) \times 9.5 = 39.31 \text{ min} = 2358 \text{ sec.}$

Since the conditions at 400,000 ft are desired, enter at h=400,000 ft and move up to *Point J* on the τ-curve established by *Point H*. Read $V_{400,000}$=26,520 fps.

Move left to *Point K* on the *e*-

more on page 134

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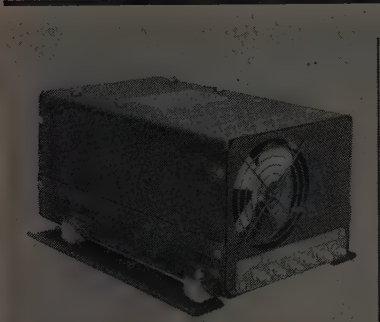

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Preference of aircraft designers has made Chatham the world's number one supplier of power conversion equipment for missiles . . . jets . . . airliners. Here's why Chatham holds this position.

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Components control: All solid-state components are made right at the Chatham plant. Thus, Chatham power supplies are never limited by "specs" of commercially available components.

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... all three with excellent drafting surface on both sides.

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... **Blacker blacks,** because PHOTACT film has a higher silver concentration than comparable film.

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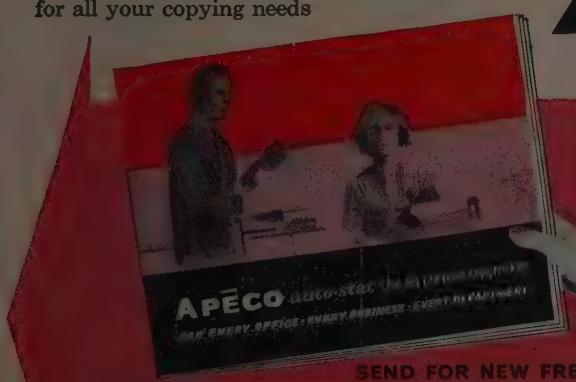

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curve established by *Point 1* and read $\theta_{400,000}$=303 deg and t= $\tau/1.16$.

Move down to *Point L* on the γ-scale and read $\gamma_{400,000} = -3.5$ deg.

Now calculate the time from apogee to the 400,000-ft point as part of the period of the orbit followed after application of the retro-thrust:

$\Delta t_2 - t_{400,000} - t_a = (1/1.16 - 1/2)\ 93 = 33.7\ min = 2022\ sec.$

The total time from burnout to re-entry then is:

$\Delta t_{er} = \Delta t_1 + \Delta t_2 = 39.31 + 33.7 = 73.01\ minutes = 4380\ seconds.$

As the retro-thrust was applied at apogee, the orbit axis was not rotated. The angular displacement between burnout and re-entry therefore is $\Delta\theta = 303 - 36 = 267$ deg.

Now determine the re-entry conditions at 400,000 ft brought about by a retro-thrust of 200 fps applied 3000 seconds after burnout as specified for *Figure 2*.

From *Figure 2* we know that the time (t) from perigee to burnout is $\tau/11.6$, or 8.19 minutes, or 491 seconds. The time from perigee to retro-thrust therefore is 491 + 3000, or 3491 seconds. This represents $3491\tau/(95x60) = 0.612\tau$.

Establish *Point M* in *Figure 4* at the intersection of the $t = 0.612\tau$ curve and the e-curve of the initial orbit. Read $\theta_{retro} = 216$ deg (which applies with respect to the initial orbit). Move down to *Point N* on the γ-scale and read $\gamma_{retro} = -2.15$ deg.

Return to *Point M*, move right to *Point O* on the $\tau = 95$ curve of the initial orbit, and read $V_{retro1} = 23{,}740$ ft, which is the velocity *before* application of the retro-thrust. Move down to *Point P* on the h-scale and read $h_{retro} = 2{,}820{,}000$ ft.

Return to *Point O* and apply the retro-thrust of $\Delta V = -200$ fps by moving down to *Point Q*, which gives $V_{retro2} = 23{,}540$ fps (the velocity *after* application of the retro-thrust). Read $\tau \approx 93$ minutes.*

Move left to *Point R* on line *M-N*. (The value for γ remains constant, for the retro-thrust is applied along the flight path.) Read e =

*The value for τ is not precisely 93 minutes, as it is in Figure 3, but we will consider it as such for simplicity's sake.

more on page 138

Eliminates antenna shading

Autonetics' new *Automatic Antenna Selector* insures uninterrupted radio reception in military and commercial aircraft. Used with dual-antenna systems, it assures a strong, continuous signal. Does away with manual switching and losses due to coaxial tees in the antenna feedlines. Simple to install... has a 10,000-hour operating life with minimum maintenance ...completely reliable during high-speed maneuvers and in environmental extremes. Meets stringent military requirements.

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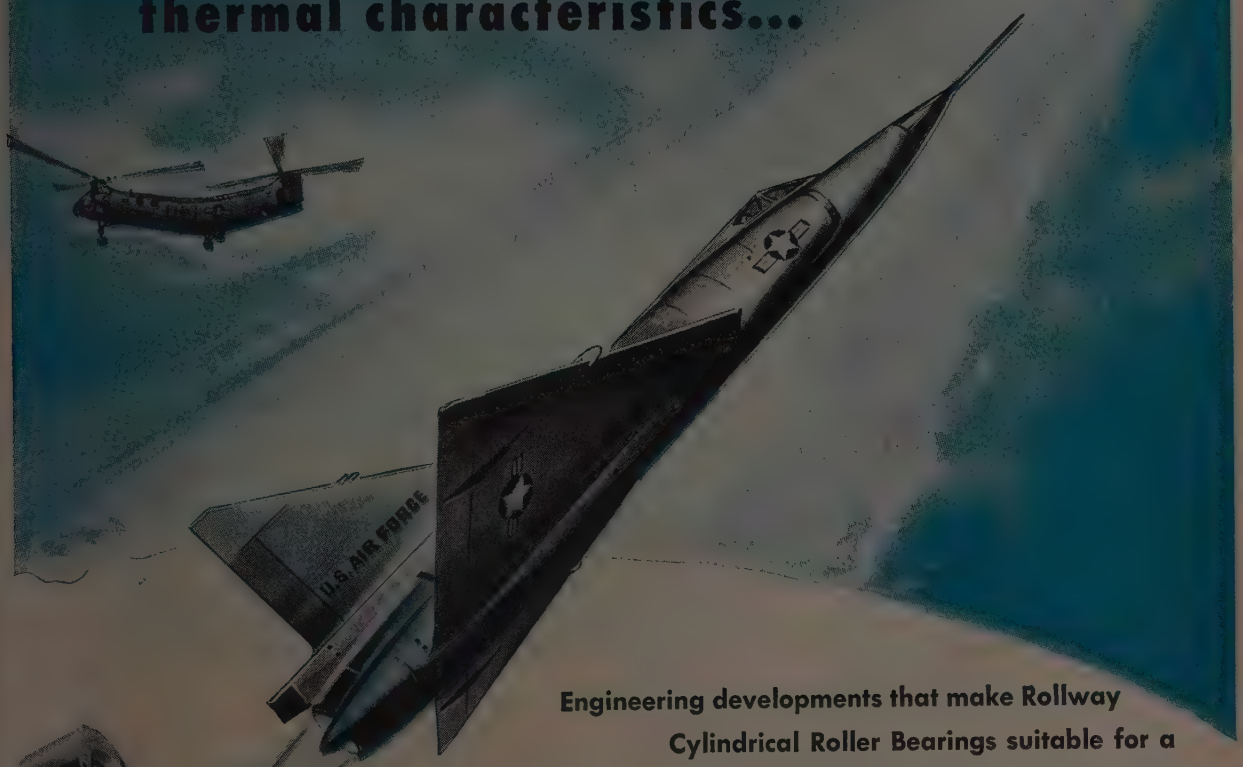
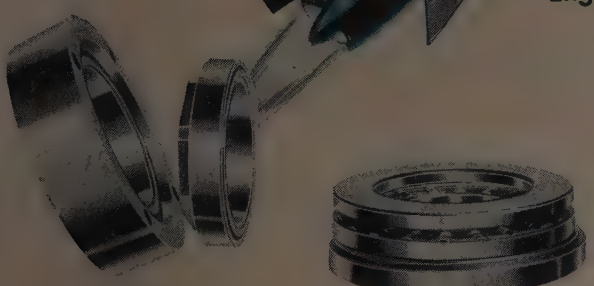


Engineering developments that make Rollway Cylindrical Roller Bearings suitable for a wide range of aircraft applications

Eight years after the Wright brothers' flights at Kittyhawk, Rollway began the production of cylindrical roller bearings. Careful inspection, metallographic checks, design evaluations and lubrication studies have steadily improved the range speed, stress, ambient and operating temperatures.

We produce the practical, while we develop the science of the possible. Our key personnel are always ready to work on experimental or production models where high-stress, high-temperature, and high-precision bearings are essential.

Illustrated are a few of the Rollway Bearings produced for general aeronautics use. Not illustrated, for obvious reasons, are Rollway experimental bearings developed for test in various projects. A wire, letter or print will initiate a cooperative relationship that could be mutually rewarding. *Rollway Bearing Co., Inc., Syracuse, N. Y.*



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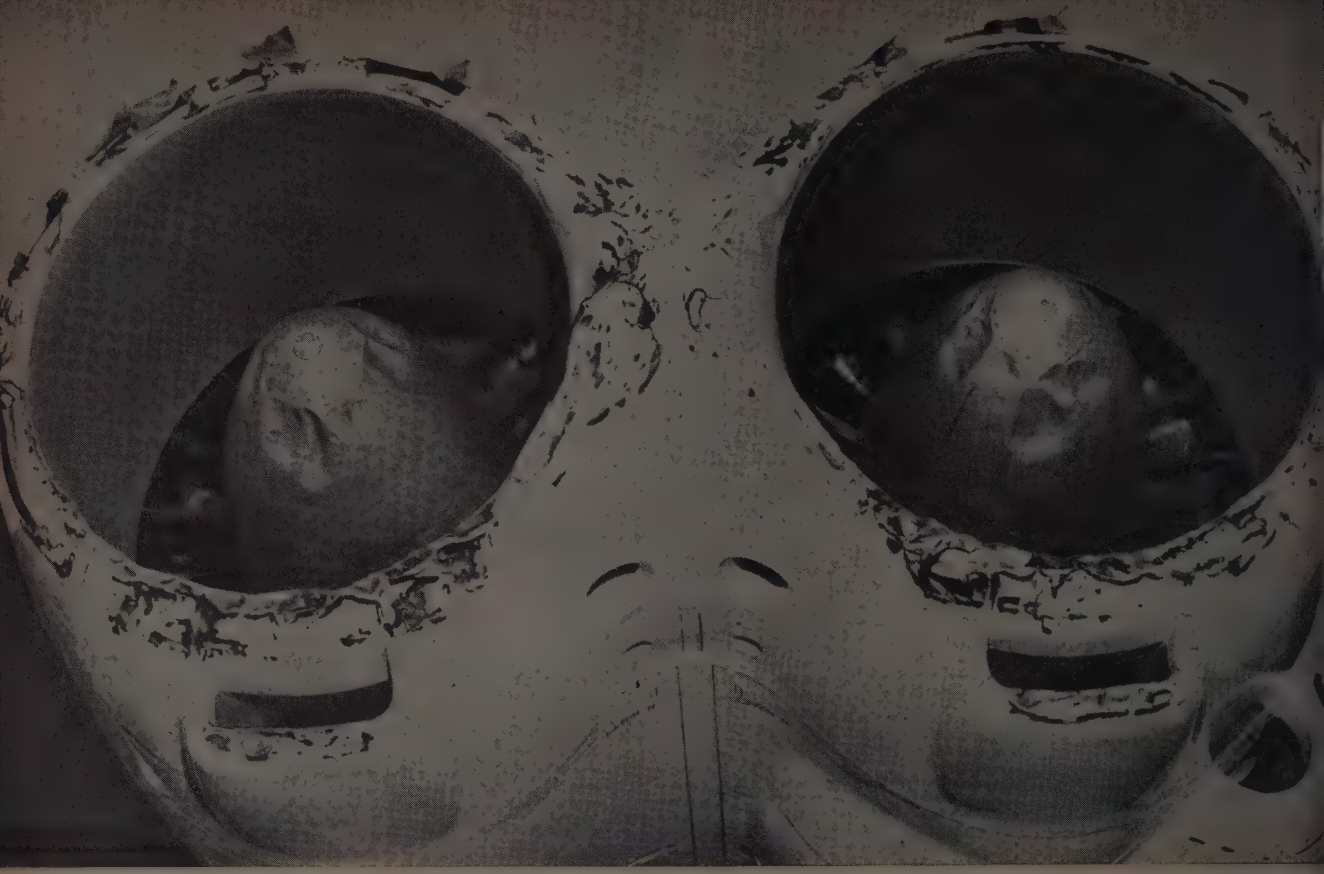

J-57 Titanium engines save nine-man crew in their $8-million B-5

At 8,000 feet, the B-52 ran into a small and very violent frontal area. Suddenly the airplane was pelted with hailstones the size of baseballs. Flying at 400 miles an hour the damage to the B-52 was terrific.

The windshield smashed. The radome was torn away. The radar antenna was demolished. Wing edges were hammered flat. Holes were punched in the wings and engine nacelles. Flying metal was sucked into the engines and disappeared. Some of the electrical system failed and most of the instruments were out. The aircraft went momentarily out of control.

Major W. F. Zerdecki, the air commander, struggled with the controls. Captain Charles L. Borgeson, Jr., the instructor pilot, sent out the distress call. The crew prepared to bail out.

By this time, the shuddering aircraft had already bucked through the storm. The eight Pratt and Whitney titanium version J-57 engines were still giving full power. Major Zerdecki climbed the B-52 to 23,000 feet where he rendezvoused with a KC-135 tanker. The B-52 crew tested their controls by instrument readings relayed by the tanker crew. The light and powerful titanium engines kept the shattered aircraft aloft for almost two hours after it hit the storm.

The performance of the J-57's in bringing safely home the nine-man crew in their $8-million ship, was described by Brigadier General Nils H. Ohman, 19th Air Division Commander:

"The engines put out all the power required. They performed perfectly. If they hadn't, Major Zerdecki would never have been able to fly the ship back."

Carl Cooper, Pratt & Whitney technical representative, reported: "All eight engines had ingested metal. Magnesium cowling pieces shattered as they went

rough the engine. Six of the engines were found to ave bits of cowling metal one-eighth of an inch long the end of the high compressor assembly and pieces f magnesium approximately the same length were ound stuck to the first stage turbine blades. The J-57 ngines, though slightly damaged, were still serviceable nd satisfactory for continued, limited, safe operation. he damage was repairable with a minimum of time nd effort."

Since 1954, some 5000 titanium engines have been ut into service containing material supplied by itanium Metals Corporation of America. More than 00,000 hours service time have been accumulated with o reports of failure of the titanium parts.

REAT STRENGTHS...The strengths of titanium, oupled with its light weight (density 0.16 pounds per ubic inch), have meant valuable fuel economies and ncreased payloads. At the same time, the excellent cor- sion resistance of titanium has reduced costly mainte- ance and parts replacement.

Steadily declining prices; advances in machining, elding and heat-treating techniques; and development f new alloys have combined to maintain titanium's role s an important engineering metal in the new engines ow in design or advanced development.

These same advantages also make titanium metal an conomical material of construction for the dead-weight rea known as airframe. For example, heat-treated tita- ium forgings can cut structural weights almost in half.

Titanium Metals Corporation of America has dedi- ated its full resources to development and production f high-strength aircraft quality material and the tech- ical assistance required to make design potentialities f the metal production realities.

This effort to build an industry has provided TMCA ith a wealth of information that is yours when you pecify Timet® titanium.

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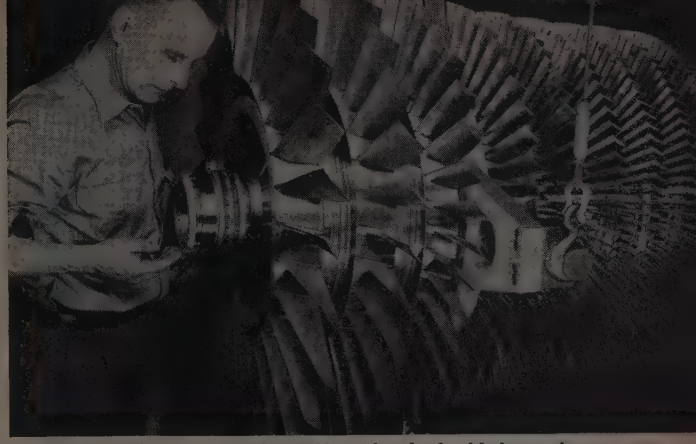
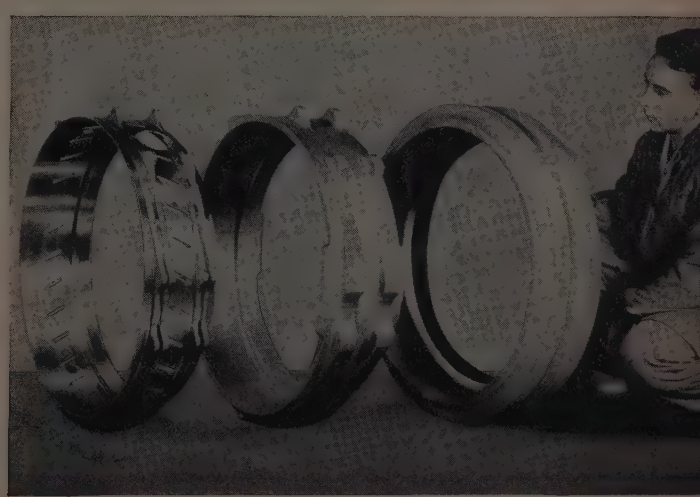


J-57 ROTOR ASSEMBLY, with wheels, blades and spacers forged and machined from TMCA titanium alloy Ti-6Al-4V. Now *new* alloys, such as Ti-7Al-4Mo —already in commercial production—extend useful temperature range and meet higher creep strengths required for engines in design or advanced development stage.

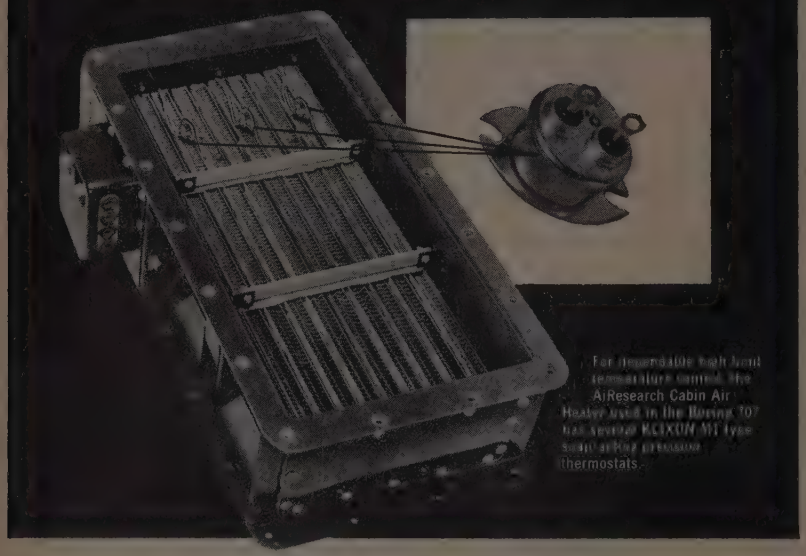
THIS INTERMEDIATE COMPRESSOR CASE ASSEMBLY is used in fighter versions of J-57 engine. Fabrication techniques include ring-rolling, welding, machining, stretch-forming, and piercing. Use of titanium saves 443 pounds per compressor.



STATOR HOUSING of titanium alloy Ti-5Al-2.5Sn, shown here in various stages of fabrication from rolled and welded ring to finish-machined part, provides important weight savings to J-57 engine.

Klixon Precision Thermostats

HELP ASSURE DEPENDABLE, SAFE OPERATION OF MANY BOEING 707 COMPONENTS



For dependable high limit temperature control, the AiResearch Cabin Air Heater used in the Boeing 707 has several KLIXON M1 type snap action pressure thermostats.

Boeing 707 Jet Airliner now in regular passenger service.

For example, on the cabin air heaters produced by AiResearch Manufacturing Division of The Garrett Corporation, KLIXON Precision Thermostats assure positive temperature protection . . . contributing to heater safety and dependability. These heaters are lightweight units which fit into the 707's main cabin air-conditioning ducts where they warm incoming air to proper temperature. The thermostats shut off the main power source to the heaters as a safety precaution in the event temperature exceeds the limit value.

KLIXON snap-acting controls are ideal for applications of this type — for several important reasons. They are small in size and light in weight; they respond to temperature change quickly and with accurate repeat performance; they have ample capacity to carry electrical loads as required; and their calibrations stand up in the face of severe environmental conditions.

Let qualified Spencer engineers assist you, too, with your temperature control requirements. They will be pleased to study your application and, if a standard KLIXON Precision Control is not available for it, they can recommend adaptations to operate or protect your particular equipment. Write today for the KLIXON Precision Thermostat Catalog. Choose KLIXON Controls with confidence.

Western manufacturers — refer inquiries to Metals & Controls Corporation, Southern California Office...232 North Lake Avenue, Pasadena, California . . . Telephone Ryan 1-4288.

METALS & CONTROLS CORPORATION

Spencer Division

3703 Forest St., Attleboro, Mass.

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0.0735, $\theta_{retro} = 208.5$ deg, and $t_{retro} = 0{,}591\tau$, all three values applying to the new orbit.

Note that, as the retro-thrust is applied at a point past the apogee, the major axis of the new orbit is rotated (with respect to the axis of the initial orbit and in the direction of motion) by:

$$\Delta\theta = \theta_i - \theta_{new} = 216 - 208.5 = 7.5 \text{ deg.}$$

Since the conditions at 400,000 ft are desired, enter again at $h = 400{,}000$ and move up to *Point J* on the τ-curve established by *Point Q*. Read $V_{400,000} = 26{,}520$ fps.

Move left to *Point S* on the e-curve established by *Point R*. Read $\theta_{400,000} = 305.5$ deg and $t = 0.866\tau$, both with respect to the new orbit.

Move down to *Point T* on the γ-scale and read $\gamma_{400,000} = -3.3$ deg.

Now calculate the time from the application of the retro-thrust to the 400,000-ft point as part of the period of the new, post-retro-thrust orbit:

$$\Delta t_2 = t_{400,000} - t_{retro} = (0.866 - 0.591)93 = 25.58 \text{ min} = 1535 \text{ sec.}$$

The total time from burnout to re-entry then is:

$$\Delta t_{re} = 3000 + 1535 = 4535 \text{ seconds.}$$

The angular distance between burnout and re-entry also is readily found as:

$$\Delta\theta = \theta_{400,000} - \theta_{retro1} + \theta_{retro2} - \theta_{bo} = 305.5 - 208.5 + 216 - 36 = 277 \text{ deg,}$$

where the subscripts *1* and *2* refer to the initial and post-retro-thrust orbits, respectively.

This nomograph was prepared for SPACE/AERONAUTICS *by H. H. Luetjen, Supervisor, Technical Integration, Preliminary Design, and M. L. Ramey, Chief Structural Research Engineer, Airplane Engineering Div., McDonnell Aircraft Corp., P.O. Box 516, St. Louis 3, Mo.*

A limited number of reprints of this nomograph is available upon request from Reprint Dept., SPACE/AERONAUTICS, *205 E. 42nd St., New York 17, N.Y.*

A Correction

Relays and antennas are still two different things, despite the Product Preview item "Time Delay Relays" in the December 1958 issue (p. 105), which by mistake showed an antenna as an illustration of a series of Curtiss-Wright relays.

DESIGN

As missile programs passed from early development to production, servovalves of increased sophistication became necessary. Keeping pace with this development, Moog has been responsible for all major servovalve improvements.

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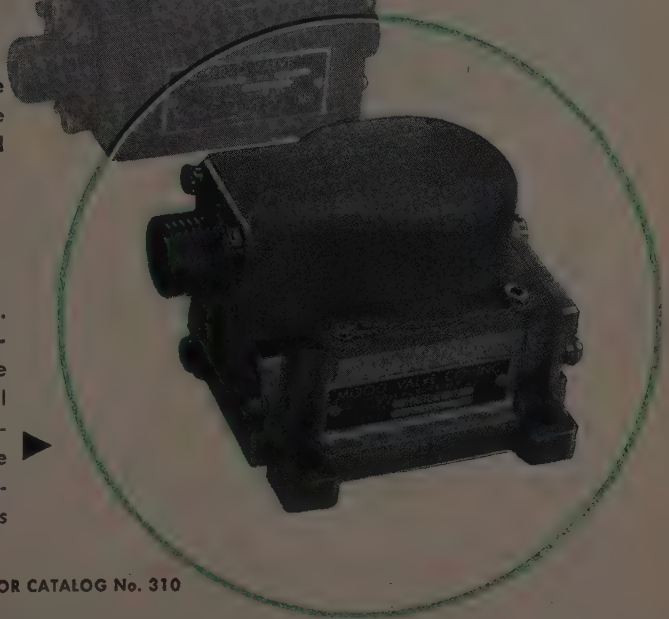
Today reliability is the key requirement for missiles. Anticipating this need, Moog has had under intensive development and test for the past year the simplest, lightest, most compact and reliable of all production servovalves. Its performance in all important respects exceeds that of any other available unit. Moog is pleased to announce immediate availability of the new Model 31 and 32 Series valves in quantity to your specifications. ▶



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THE RYAN ROLE IN JET TRANSPORT

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For the Boeing KC-135 jet tanker, Ryan manufactures mammoth 40-foot-long fuselage sections—the first double-contoured aircraft structures to be spotwelded under automatic production methods. This technique, developed by Ryan, provides an aerodynamically smooth structure, fabricated by weightless methods, that resists metal fatigue at jet speeds and altitudes.

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Size 15
Wt.: 160 grams
Diam.: 1.437 ins.

Size 8
Wt.: 32 grams
Diam.: .750 in.

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Highest accuracy in rotating components is a CPPC fundamental. Our Precision Computing Resolvers are no exception. Without compensation, a recent production run of resolvers showed functional errors of .06% *or less.* Perpendicularity of axes was ±3′ in 360°. Due to extreme symmetry of rotor and stator, nulls are excellent in these resolvers. Low phase shifts are also a feature.

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CPPC Precision Computing Resolvers can be had with any of the following features: corrosion resistant construction, stainless steel or aluminum housing. Units to resist temperatures up to 450° F. The following compensation is available in any or all units: resistive, feedback winding, thermistor. Types available for transistor circuitry. Pin or screw terminals or lead wires. BuOrd type shafts and BuOrd MK 4 Mod 0 brush block obtainable.

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We ask you to review what you are paying for precision computing resolvers. In the past CPPC has been able to lower traditional prices of rotary components.

We are already tooled for many types of these resolvers and can make quick delivery in quantity or short run. Whenever you need *any* rotary component, think of CPPC.

Call or write Sales Department, HIlltop 9-1200 (Suburban Philadelphia) or our Representatives.

ENGINEERS—For a career in rotary components and computers, write David D. Brown, Personnel Director, Dept. J3

cppc **CLIFTON PRECISION PRODUCTS CO., INC.**

CLIFTON HEIGHTS, PENNSYLVANIA

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NASA'S SPECIALLY EQUIPPED McDonnell F-101 may have more electronic computation hardware per cubic foot than any other aircraft now flying. The research jet will carry both a digital differential analyzer and a straight digital computer. Autonetics is building the former, a 900-lb, 21-cu ft unit (including multi-recorders). The digital brain is being made by Burroughs, will include a ferrite-core random access memory.

Controls and a stable platform for the F-101 are to be supplied by Sperry Gyroscope. Bendix Eclipse-Pioneer will furnish the air data computer.

SCHEDULED FOR DELIVERY by the end of the year, the F-101 will be used by NASA to study adaptive controls, digital autopilots, automatic landing, unusual aerodynamics and special pilot problems. It will be able to simulate such future airplanes as North American's B-70 and F-108 and re-entry vehicles such as the X-15 and Dyna-Soar.

"Hundreds of miles" covered "exactly" in test flight of Atran guidance

ATRAN, map-matching radar guidance developed by Goodyear, was tried out in a Douglas C-47. Using synthetic film (made of a special map model of the terrain), the C-47 flew "exactly prescribed courses covering hundreds of miles," says Goodyear.

The map matcher, which is used in the Martin Mace missile, gets its guidance signals from comparison of the radar image of the terrain with stored actual or synthetic films. The C-47 trials imply that Goodyear is pushing the system as a self-contained aircraft navaid.

TWO QB-47 DRONES are being completed by Lockheed and Sperry Gyroscope. Both bombers will be equipped with optical and electronic firing error indicators to evaluate effectiveness of ground-to-air and air-to-air defense systems. Drones will also have chaff dispersers and electronic jammers to confuse attackers.

SOLID-STATE GAIN CHANGERS are high on "most wanted" list of WADC's Flight Control Lab. The Lab would also like to see more work on hot gas and pulse-modulated servos as well as on sensors that can measure higher-order derivatives, such as rate of change of acceleration (also called "jerk" and "accelo-vel").

ADAPTIVE CONTROL is seen by Army Signal Corps as a vital need in future high performance drones. The Corps would eventually like to see adaptive control in all Army flight vehicles.

EAGLE MISSILE DEFENSE-SYSTEM will include airborne radar, digital computer, operator's displays, the supersonic missile itself, and "new, secret guidance" devices to be developed in part by Sanders Assoc., Nashua, N. H. Eagle will be launched from a relatively slow, long endurance aircraft yet to be selected. It is to be used against aircraft and aerodynamic missiles.

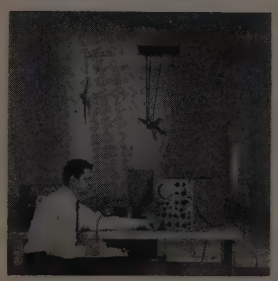
Eight-inch parabolic scanner is used by semi-active Sparrow III radar homer

SPARROW III'S semi-active radar homer uses an eight-inch parabolic scanner. The all-weather bird has a five-mile range, is designed for launch from McDonnell F3H2 and F4H1. Already operational with the fleet for some four months, it has knocked down Mach 2 targets.

TRANSPARENT POTTING COMPOUND under development at Dow Corning, should be a boon to electronic maintenance. Components can be seen through the material, and defective ones are easily replaced by being cut out of the compound with a knife. After the component is replaced, new compound can be poured in. Material will harden at room temperature.

ULTRAVIOLET "DEATH RAY" is predicted by Professor Eugen Sänger, well-known physicist at West Germany's Stuttgart Institute of Technology. Writing for "The Next Ten Years in Space," a staff report of the Congressional Committee on Astronautics and Space Exploration, he describes the lethal ray as a "stationary ultra-

more on next page



Cover story — Noise-free room at Republic Aviation was set up to optimize location of F-105's array of 14 antennas for plane's 10 electronic systems. Engineer is beaming HF radio signals from transmitter horn to copper-coated model.

searchlight" that might exert a radiation pressure by means of high energy beams and so destroy flying objects up to a distance of several hundreds of miles in a fraction of a second." (Before World War II, Robert Watson-Watt was asked by the British government to look into the possibilities of an electromagnetic death ray. He decided such a device was not feasible—at least with the components available at the time. But his studies led him to the discovery of radar.)

Satellite use for atomic clock accurate to ±3 deg in 1000 years?

GAS CELL ATOMIC CLOCK just unveiled by International Telephone & Telegraph Labs is accurate to ±3 seconds in 1000 years. A device of such accuracy could be used on an earth satellite to measure gravitational fields in space and so check the time-gravity aspects of the relativity theory.

BREAKTHROUGH is what Signal Corps R&D Lab and Tung-Sol Electric are calling their joint development of a magnesium-oxide, cold cathode tube. In a mass production process evolved by Tung-Sol, thin coatings of MgO are sprayed on a nickel base. Emission is started with a single instantaneous flash of a tiny tungsten starter filament, which bombards the MgO layer with high energy electrons. This causes sustained secondary emission from the cold cathode to a collector electrode.

Original experiments showed that, by varying the voltage at the collector electrode, this self-sustained current can be easily controlled for many hours from a few microamps to several tens of milliamps. Production experiments disclosed that the ability of the MgO to render self-sustained emission depends closely on the methods of preparing the layers. A certain degree of porosity was needed, and the layers worked best when heat-treated with O_2.

Secondary emission of MgO tube not fully understood

IT'S NOT YET fully known what factors are producing secondary emission. Theory is that, when electron emission is started from a MgO cold cathode, a positive charge is developed at the surface of the first MgO layer. Since the cathode coating is very thin, a high electric field is developed between it and the next layer. This field draws electrons from the second layer, which in turn sets up another high electric field between itself and the third layer, and so on in an avalanche effect.

In this way, the electrons liberated within the MgO are multiplied by an avalanche process and gain enough energy to leave the MgO and enter the vacuum. This concept, it's noted, must be considered only as a first approximation. Many details still have to be clarified to validate it.

TUNG-SOL SO FAR has produced only one pre-production tube—an audio output amplifier developing 900 mw. It takes only 0.75 W to run the cathode; plate power is the same as for thermionic tubes.

Advantages of the cold cathode are: lower operating power needs, quick starting, longer life (14,000 hours of continuous operation in a lab socket), no heater troubles. At the present state of development, a minimum voltage of 300 V (cut to 190 V in lab tests) is needed for operation. Also, present units are not self-starting and slightly more complex inside than conventional tubes.

TUNG-SOL IS WORKING on a cold cathode electron gun for use in CRTs, klystrons, and TWTs. In the design state is a flat display device for radar use. Further applications include electronic computers, where elimination of the heater would increase reliability and reduce total power drain, and satellite equipment where the low power drain would make operation on solar batteries more feasible.

Off-the-shelf items to be used for electronics of Mercury space capsule

COLLINS RADIO'S subcontract from McDonnel (amounting to some $2.5-3 million) for instrumentation for NASA's one-man Mercury spade capsule includes: radio voice communications, a telemetering system to relay capsule records and medical data on the man aboard to ground stations, an orbit-tracking system, and a rescue radio beacon for recovery of the nose-cone-shaped payload after re-entry.

So far as possible, the package will be made up of off-the-shelf items, SPACE/AERONAUTICS learned. Still Collins stands to gain much in the way of recognition as a firm experienced in space vehicle CNI. (It also produced the communications and navigation equipment for the X-15).

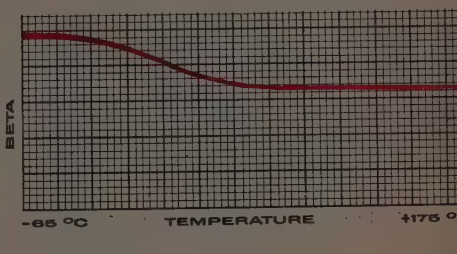
RCA PRESIDENT John L. Burns, predicts '59 will bring an 11 per cent increase in electronics business. "The total volume in the electronics in-

more on page 146

5 new RCA DIFFUSED-JUNCTION MESA Silicon Transistors

...with excellent beta stability from −65°C to +175°C and exceptionally low saturation resistance!

- 2N1092—low power
- 2N1067—medium power
- 2N1068—medium power
- 2N1069—high power
- 2N1070—high power



RCA's new n-p-n silicon transistors offer significant reductions in saturation resistance, and feature excellent beta stability over the entire operating temperature range. These features result from use of RCA's advanced diffused-junction mesa technique. These transistors are designed to meet stringent military environmental, mechanical, and life test requirements.

RCA silicon transistors offer the equipment designer a wide choice of power-switching capability in preferred industry cases (JEDEC TO-3, TO-8, and TO-9).

RCA SILICON TRANSISTORS are commercially ava able in limited quantities. Your RCA Field Representative h complete information on these units and will be glad to di cuss with you other silicon transistors now under develo ment. For technical data on the 2N1092, 2N1067, 2N106 2N1069, and 2N1070, write RCA Commercial Engineerin Section C-59-NN Somerville, N. J.

Type	JEDEC Outline	RATINGS				CHARACTERISTICS								
						At Case Temperature of 25°C						At Case Temperature of 175°C		
						Saturation Resistance (ohms)			DC Current Gain (Beta)			DC Collector Cutoff Current (Icbo) (μa)		
		Vces● (volts)	Vceo▲ (volts)	Collector (amp.)	Transistor Dissip. # (watts)	Typical	Max.	Conditions	Typical	Min.	Conditions	Typical	Max.	Conditions
2N1092	TO-9	60	30	0.5	1	3	10	Ic=200 ma.	20	10	Ic=200 ma.	75	1000	Vcbo=30 volts
2N1067	TO-8■	60	30	0.5	2.5	3	10	Ic=200 ma.	35	15	Ic=200 ma.	75	1000	Vcbo=30 volts
2N1068	TO-8■	60	30	1.5	5	1	2.67	Ic=750 ma.	38	15	Ic=750 ma.	75	1000	Vcbo=30 volts
2N1069	TO-3	60	45	4	25	0.7	2	Ic=1.5 amp.	20	10	Ic=1.5 amp.	150	2000	Vcbo=30 volts
2N1070	TO-3	60	45	4	25	0.4	0.67	Ic=1.5 amp.	20	10	Ic=1.5 amp.	150	2000	Vcbo=30 volts

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dustry is expected to rise from nearly $14 billion in 1958 to well over $15 billion this year," he says.

Burns forecasts a rise of over 70 per cent in the electronic data processing market, which will reach $600 million this year. Sales of defense electronics he expects to rise at least 14 per cent over '58's $3.6 billion.

Printed circuit production this year to come to $35-40 million

THE MICROMODULE is a significant breakthrough, Burns points out. Printed circuits too, have come of age—some $35-40 million worth are expected to be produced this year, he notes —an 800 per cent increase over five years ago. Their reliability has been fully demonstrated. Under the Sage system, Burns states, "when a man presses a button in Kingston, N.Y., to fire a missile from Cape Canaveral, Fla., to intercept a drone target at sea, every function from beginning to end is carried out through sealed—etched or stamped—circuits."

TWENTY TIMES BRIGHTER display is claimed by ITT Labs for an airborne radar indicator in bright-screen cockpit instrumentation. The brightness of the display allows pilots of supersonic aircraft to scan target blips on their cockpit scopes in-full daylight without using hoods.

Behind this improvement is a five-inch Iatron direct-view storage tube with a brightness potential of about 3000 ft-lamberts. The two-gun, read-and-write tube stores weaker radar target echoes and reproduces them by a form of video integration as distinct signal traces above the noise interference. The tube, reportedly is capable of extremely high resolution.

THE 6x6x13-IN. RECEIVER is being produced at ITT-Federal under a Navy contract. Good results are being reported by pilots flight-testing Douglas' cockpit instrumentation for use in advanced Navy and USAF attack planes.

Metal-ceramic tube upped Juno II tracking accuracy

GE'S METAL-CERAMIC TYPE 7707 receiving tube, used as a transmitter in the Army's 66,000-mile Juno II moon shot, made for greatly increased tracking accuracy, reports a GE spokesman. It enabled JPL to get about 200 mw output at 960.05 mc with its spaceborne transmitter.

For this "out-of-spec" application, GE supplied JPL with specially evaluated tubes picked from its production lines. They gave a 20:1 power gain (13 db) in the Class B amplifier circuit that was used, amplifying the 10-mw output of a transistor oscillator to a 200-mw level for HF tracking.

The power supply in the JPL system probably was designed for only several days' operation. Current work on supplies and tube design should extend transmitter life considerably, says GE.

FIRST use of the metal-ceramic tube in production equipment may be that of six 7707s in the RF stages of the ARC-52, military comm system in production at Collins Radio. The 7707's small size (0.44x0.48 in.) and low noise as well as its high gain qualities, led Collins to pick it for RF amplifier and mixer circuits.

Shipboard radar uses shaped pulse to cut interference from other electronic gear

WESTINGHOUSE REPORTS it successfully fulfilled a Navy contract for a new search radar specially designed for operating in the midst of the crowded array of electronic equipment found on the latest combat ships. Extremely high stability is achieved by crystal control. Also, getting away from the more common rectangular pulse, the radar uses a shaped pulse to cut the operating bandwidth and allow it to operate among adjacent radiative gear.

Design includes self-testing circuitry and grouped major control junctions and condition indicators for simplified maintenance.

MINNEAPOLIS-HONEYWELL got subcontract from McDonnell for a stabilizing and control system for the manned Mercury space capsule. M-H's system of gyros and electronics essentially will take over control of the capsule in the manner of the human inner ear. The capsule's human occupant will be completely disoriented by the weightlessness phenomenon.

The system will control a series of small reaction jets and retro-rockets to keep the capsule from tumbling, to keep it pointing butt-end first in its orbit, and to control it during re-entry. It will also trigger the capsule ejection system should a malfunction occur while the capsule is attached to the missile and automatically energize such safety features as parachutes, ballons, and signalling devices. M-H is to furnish stabilizing and control systems for at least 12 capsules, SPACE/AERONAUTICS learned.

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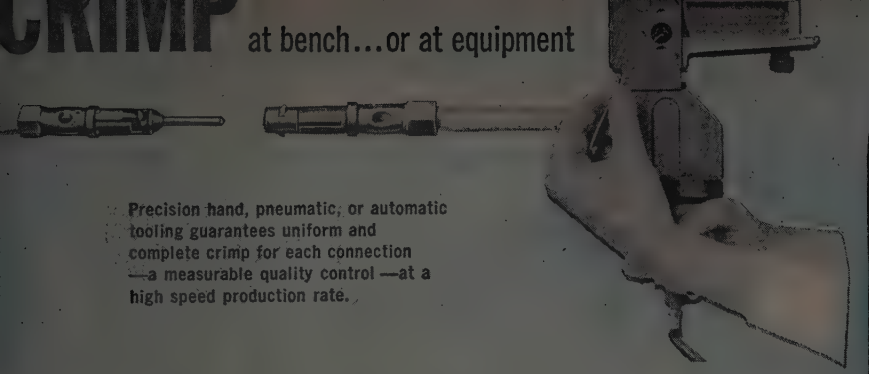
CRIMP at bench...or at equipment



Precision hand, pneumatic, or automatic tooling guarantees uniform and complete crimp for each connection —a measurable quality control —at a high speed production rate.

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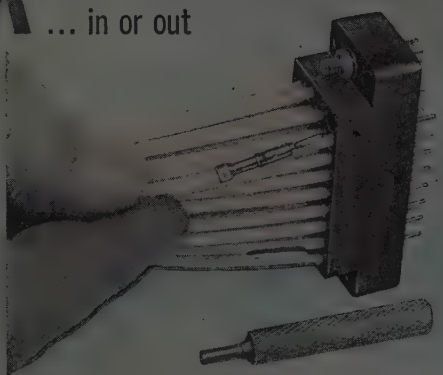

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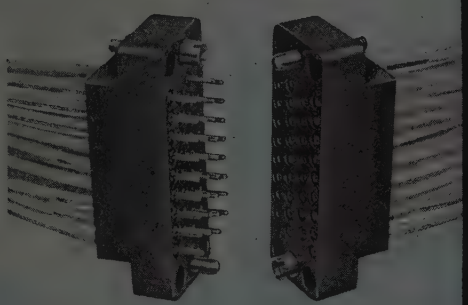

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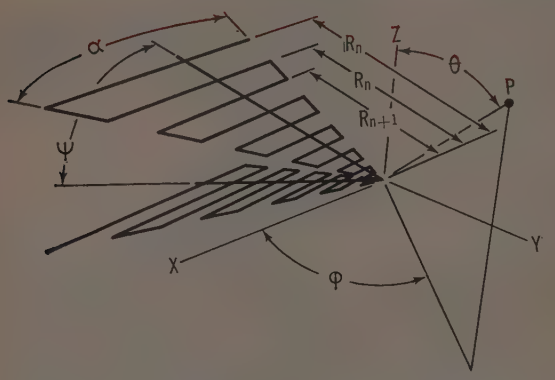

FIGURE 1: Parameters for a log periodic antenna with $\tau = R_{n+1}/R_n = l_{n+1}/l_n$ and $r_n = \sqrt{\tau}\, R_n$.

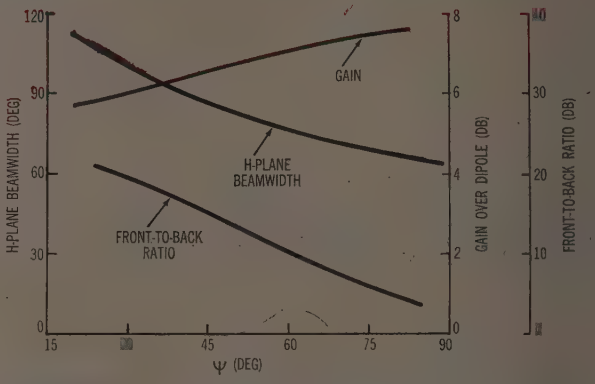

FIGURE 2: Effect of ψ on pattern characteristics of an antenna with $\alpha = 60$ deg and $\tau = 0.6$.

Log periodic antennas

break bandwidth barriers

With bandwidths of 20:1 or even 100:1, a single logarithmically periodic structure now can do jobs for which as many as a dozen antennas once were needed. The new structures will find use in airborne and ground communications, search, and countermeasures systems.

by R. H. DuHamel, Head, Antenna Design Group, Research & Development, Collins Radio Co.*

THERE has been an ever increasing demand for extremely wideband components for countermeasure, communications, direction-finding, and search systems. In the past, system bandwidth very often has been limited by antenna bandwidth. For example, transmitters and receivers with bandwidths of 10:1 or 15:1 have been available for many years, but the bandwidths of available antennas were at most 3:1 or 4:1. To meet system requirements it was necessary to use several antennas—and put up with greater complexity.

This situation has been changed by two new design methods—simple and basic but very important—that have evolved over the last few years. Today, antennas can be built with electric characteristics that are essentially independent of frequency over theoretically unlimited bandwidths. ("Electrical characteristics" here refers to such parameters as input impedance, radiation pattern, gain, and polarization.) Antenna bandwidths of 20:1 or 100:1 are available for many uses.

The shoe now is suddenly on the other foot—the transmitter, receiver, and transmission line engineers must extend the state of the art on bandwidth to match the available antenna bandwidths. They can also no longer justify the use of narrow antenna bandwidths to eliminate harmonic or spurious emissions and responses.

One of the new methods uses the "angular concept", which defines the geometry of the antenna as much as

*Collins Radio Co., 855 35th St., N. E., Cedar Rapids, Iowa.

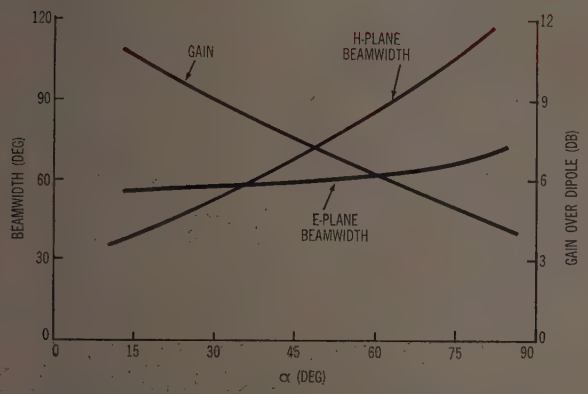

FIGURE 3: Effect of α with $\psi = 30$ deg and τ varying from 0.85 to 0.6 as α varies from 15 to 75 deg.

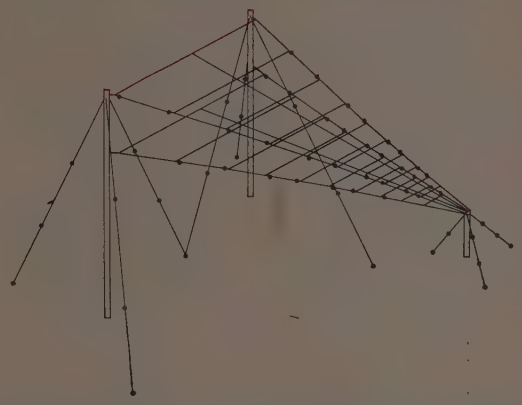

FIGURE 4: Log periodic antenna placed to give pseudo-frequency-independent vertical-plane pattern.

possible by angles rather than distances.[1] Examples are the biconical, discone, bow tie, and equiangular spiral antennas.

The other method uses the "log periodic concept", which defines the geometry of the antenna so that the electric characteristics must vary periodically with the logarithm of the frequency.[2,3] The two concepts are closely related; it can be argued that each is a special case of the other. At this time, the log periodic approach appears to be the more versatile one.

Figure 1 shows one of an infinite variety of log periodic antenna types. The two half-structures are formed by transverse wires whose extremities are alternately connected by radial wires and whose centers are connected with wires running the length of the structures.

Structures fed against each other

The two structures are fed against each other at their vertexes by a balanced two-wire line or a coaxial line running along the center of one structure. The angles α and ψ define the extremities of the transverse wires and the orientation of the two half-structures. The lengths of the transverse wires or the distances of the wires from the feed point are arranged so that they form a geometric sequence of terms. The geometric ratio τ, defined in *Figure 1* by R_{n+1}/R_n, determines the periodicity of the structure.

If the structure were of infinite extent, it can be seen, the electric characteristics would be the same for any two frequencies related by some integral power of τ. When these characteristics are plotted on a logarithmic frequency scale, these frequencies are equally spaced, with a separation, or period, of $\log 1/\tau$. So the characteristics, such as radiation pattern and input impedance, must recur periodically with the log of fre-

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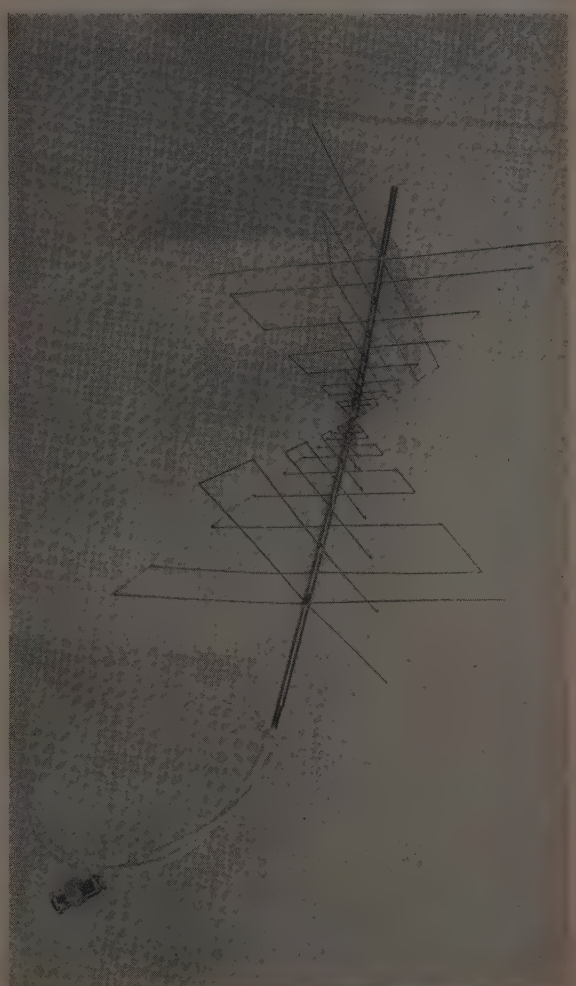


FIGURE 5: Horizontally polarized omnidirectional log periodic antenna uses two planar log structures placed at right angles to each other.

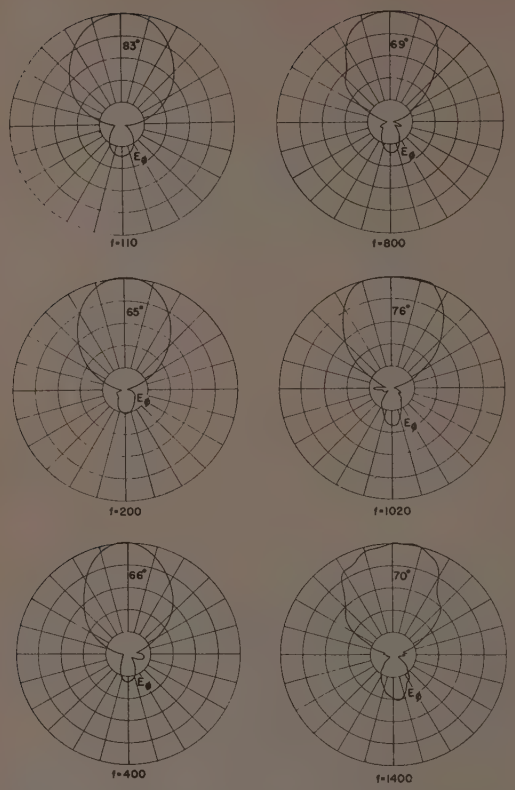


FIGURE 6: E-plane patterns showing essentially frequency-independent operation over a bandwidth greater than 10:1.

quency—and hence the name "log periodic" antennas.

If the defining parameters can be adjusted so that the variation of electric characteristics over one period is small, then this will hold true for all periods. The result is an extremely broadband antenna. A period of frequency is defined as the range from τf to f.

Fortunately, it has been found that, even with finite structures, there are several types of log periodic configurations for which the log periodic variation is negligible. Unfortunately, log periodic antennas are too complex for analysis by available theoretical methods but must be studied with the help of logical experimental techniques. Their repetitive nature greatly simplifies the initial experimental study—the characteristics have to be measured only over one period of frequency. Operation over other periods then can readily be predicted.

The antenna in *Figure 1* produces a unidirectional beam in the direction of the positive Y-axis (i.e., the direction in which the structure points) with horizontal polarization. The low frequency limit of the antenna occurs when the longest transverse element is about half a wavelength long. As the frequency is increased, the portion of the antenna used to produce the beam decreases.

Going away from the feed point, the magnitude of the currents drops off quite quickly after the point at which a half-wavelength-long transverse element exists. The high frequency limit point is reached when the shortest transverse element is about three-eighths of a wavelength long.

The pattern characteristics are very similar to those you get when the two half-structures are replaced by two three-element Yagi antennas. The half-structures have a characteristic impedance of 70-200 ohms, depending on the values of the design parameters. Although the input impedance is not quite frequency-independent, the VSWR of the input impedance referred to the characteristic impedance is less than 1.5:1 or 2:1 over the bandwidth of the antenna. (Other versions of log periodic structures are shown in the references.)

Compromise between gain and size

Figures 2 & 3 show how some of the electric characteristics depend on the design parameters of the structure in *Figure 1*. *Figure 2* plots H-plane (YZ-plane) beamwidth, front-to-back ratio, and gain against ψ, with α and τ held constant. When ψ equals 180 deg, a bidirectional beam is produced.

The E-plane (XY-plane) beamwidth is nearly independent of ψ; its value is 63 deg. Note that if both gain and front-to-back ratio are to be high, a compromise value must be chosen for ψ.

Figure 3 shows the variation of beamwidths and gain with ψ held constant. We can see that the E-plane beamwidth is nearly independent of α. For high gain, it can also be seen, small values of α are needed. On the other hand, since the length of the longest transverse element is fixed for a given low frequency limit, the total length of the structure must be increased as α decreased. A compromise between gain and size of the structure has to be made.

There are many uses in the range from several to about 10,000 mc for which log periodic antennas are ideally suited. Below 1000 mc, wire-type structures, and above 1000 mc, metal sheet or printed circuit structures are more practical.[3]

Ground-to-air and ground-to-ground HF communications, for instance, demand antennas with extreme bandwidths (2-30 mc). A general-purpose but versatile antenna for this area is the Collins 237A-2 unidirectional type (*Fig. 7*). It is rotatable and covers 11.1-60 mc with a *VSWR* of less than 2:1. It provides a horizontally polarized unidirectional beam with a free-space gain of eight decibels over an isotropic antenna. Sidelobes are more than 16 db down.

The free-space pattern of the 237A-2 has azimuthal and vertical plane beamwidths of 65 and 90 deg, respectively. Power handling capacity is 50 kw. Tower height is 84 ft, and the longest element is 46.8 ft. Two similar antennas, have been developed for the 6.5- 60- and 19-60-mc ranges.

Figure 6 gives the E-plane radiation patterns for the structure in Figure 7 over a frequency range of nearly 13:1. These patterns show only a small variation over an extremely wide band.

The H-plane patterns show similar frequency independence. The values of the parameters chosen for this structure are α=60 deg, ψ=37 deg, and τ=0.6.

Figure 4 shows a log periodic antenna that may prove useful for point-to-point HF communications circuits. Except over very short distances, such communications use radio waves reflected from the ionosphere.

The vertical angle of arrival or departure (from the ground) depends on the distance between points and the height of the reflecting layer. Although it ranges from 70 down to a few degrees for different circuits, its value for a particular circuit is relatively constant

(since the height of the reflecting layer doesn't change greatly).

However, because of changing ionospheric conditions during the sunspot cycle from night to day, the operating frequency must be shifted over bandwidths of 4:1 or 5:1. So it is highly desirable to have an antenna with a main lobe whose vertical angle is independent of frequency.

Present antennas (dipole, rhombic, billboard, discone, etc.) won't meet this requirement. But if the antenna of *Figure 4* is placed so that the feed point, or front end, is at ground-level, then the vertical-plane pattern will be independent of frequency. The reason is that the distance of the phase center of the antenna from the feed point is proportional to the wavelength. So the height of the phase center above the ground (measured in wavelengths) is independent of the wavelength, which means the vertical-plane pattern is independent of wavelength.

In practice, the feed point is placed slightly above the ground to protect personnel from high RF voltages. The direction of the main lobe may be controlled by the height of the two tall towers; the size of the structure is determined by the lower frequency limit.

Although the gain for this antenna is only moderate (8-14 db over a dipole), it is used to the maximum over the complete frequency range. Other antennas that may have high gains (such as rhombics and billboards) have main beams that are not pointed at the desired vertical angle over the entire frequency range. As a result, the designer often is limited to far less than the full gain.

Ideal for reflector and lens antennas

An omnidirectional, horizontally polarized antenna consists of two planar log periodic structures placed at right angles to each other and proportioned so that they give omnidirectional radiation patterns in a plane transverse to the axis of the antenna (*Fig. 5*). Wideband, vertically polarized omnidirectional antennas (such as the discone) have been designed before, but this is probably the first frequency-independent horizontally polarized omnidirectional antenna. This type of antenna, too, will prove useful for HF communication circuits.

Since the log periodic structures have radiation patterns that are essentially independent of frequency, they are ideally suited as feeds for reflector and lens antennas. *Figure 8* shows a unidirectional log periodic feed being used with a 15-ft parabolic reflector. Bandwidths of 10:1 are easily achieved with this type of feed.

Although the pattern of the feed is essentially frequency-independent, the secondary pattern of the dish will be frequency-dependent, since full use is made of the dish aperture over the frequency band. Whenever maximum gain is needed—as in communications or search—this is desirable.

When moderate gain and frequency-independent radiation patterns are required, arrays of log periodic structures may be applied.[4] Rather small values of α are used, and all the elements are placed so that their feed points are adjacent to each other—in other words, the positions of the elements with respect to each other are defined by angles rather than distances. Gains of 15-20 db are feasible with this technique.

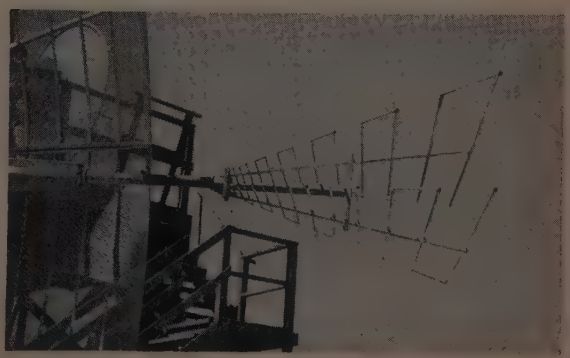
Arrays of the log periodic elements may also be arranged to produce circularly polarized bi- or unidirectional beams. Simple switching of the feed lines to the arrays can change the sense of the circular polarization.

In the near future, many new types of wideband antennas will appear. Whether they are log periodic, angular or take other form, they will have quite an impact on system design. In systems such as ground-based or airborne ECM, CECM, and search, it may become possible to cut the number of antennas by a factor of three or four.—End

References—(1) V. H. Rumsey, "Frequency Independent Antennas;" *1957 IRE Nat. Conv. Rec.*, I/114. (2) R. H. DuHamel & D. E. Isbell, "Broadband Logarithmically Periodic Antenna Structures;" 1957 *IRE Nat. Conv. Rec.*, I/119. (3) DuHamel & F. R. Ore, "Logarithmically Periodic Antenna Designs;" *1958 IRE Nat. Conv. Rec.*, I/139. (4) DuHamel & D. G. Berry, "Logarithmically Periodic Antenna Arrays;" *1958 IRE Weson Conv. Rec.*, I.

FIGURE 7: Collins 237A-2 rotatable HF unidirectional log periodic antenna for 11.1-60 mc.

FIGURE 8: Log periodic antenna used as feed for 15-ft parabolic reflector.



design digest

by James Holahan
Electronics Editor

Adaptive controls for future automatic flight

WIDENING flight regimes for aircraft, missiles, and spacecraft are fast making today's open-loop-type controls unjustifiably complex. Yet controls must also become more precise and reliable. The answer, experts feel sure, lies in self-adaptive systems, an entirely new class of controls: *intentionally non-linear feedback systems that can be designed in a straightforward and logical manner.* An adaptive control adapts automatically to its own system parameters in closed-loop fashion to get the best dynamic performance for its vehicle (correcting for environment and mass loading changes). Broadly, it either (1) uses the "passive" adaptation inherent in a high gain system with ordinary linear feedback or (2) is a non-linear system in which the structure of the controller is altered as a function of measured system response. Adaptive methods could lead to controls capable of a certain amount of learning and hence able to simulate some human functions.

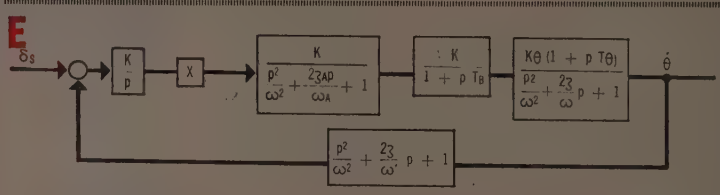
ADAPTIVE CONTROL SCHEMES—Five basic techniques appear to be in the vanguard in adaptive flight controls. Aeronutronics Systems' method (A) is the most sophisticated and complex. It alone attempts a continuous, direct measurement of the complete process dynamics. System characteristics are found by cross-correlating impulse response with a white noise stimulus. The cross-correlation produces the weighting function that sets damping ratios. [$X_i(t)$ is white noise input of unit spectral density; $X_o(t)$, output; $g(\tau_i)$ weighting function, equaling the cross-correlation function of output and input delayed by a time interval τ_i; and the bar over the cross-correlation function indicates time average.]

In the MIT system (B), the vehicle output is compared with the output of a model (a passive network with the dynamic specs of the desired system). The difference (a generalized error) is used to adjust certain loop sensitivities and compensation parameters so as to null or minimize a preselected integral function of the generalized error. If the adaptive loop fails, the process is controlled in regular feedback fashion. (Lear will mechanize and flight-test MIT's system under WADC contract.)

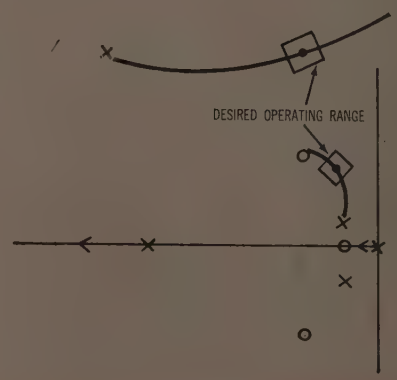
Sperry's approach (C) is in effect a non-linear "bang-bang" controller superimposed on a proportional control system. The adaption stems from that inherent in a high gain control system with linear feedback around an optimum responsive model. The system is pulsed periodically; its response is shaped into a series of fixed amplitude pulses. These are counted, and their number is the criterion for setting autopilot gain. A performance computer automatically seeks maximum attainable autopilot gain within specified stability limits. Sperry's concept has been used in analog simulator trials to control an exit and re-entry vehicle with both aerodynamic and reaction controls.

Minneapolis-Honeywell's technique (D) is built around an optimum response model, as are all the other systems. Control actuation direction depends on the signs and magnitudes of error and error rate. A continuous dither signal is imposed, and gain is automatically shifted to keep the limit cycle oscillation period essentially constant.

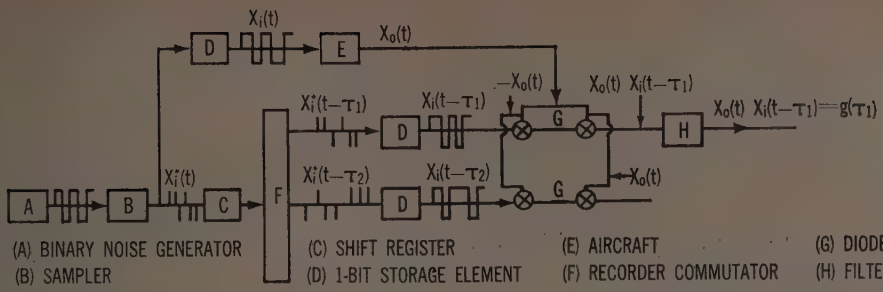
In General Electric's system (E), the controlled variable is the vehicle's angular rate. For a fixed multiplier position, the system is linear, with the feedback transfer function in the form of a quadratic. The system is made adaptive by controlling the open-loop gain through a frequency-sensitive servo that varies multiplier gain as a function of deviations from the closed-loop frequency. The root locus of the system has the characteristics shown. The loci of interest are the ones starting at the airplane and parallel actuator poles. Blocks indicate the desired operating ranges. For the feedback configuration shown, the value of the open-loop gain is such that operation is within the desired blocks.



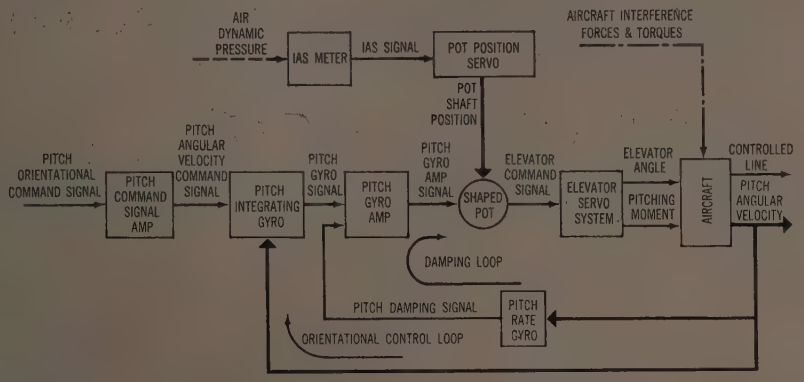
δ_S—STICK DISPLACEMENT
ω_A—PARALLEL ACTUATOR RESONANT FREQUENCY
ζ_A—PARALLEL ACTUATOR DAMPING RATIO
ω—VEHICLE SHORT PERIOD FREQUENCY
ζ—VEHICLE SHORT PERIOD DAMPING RATIO
$K\theta$—VEHICLE SHORT PERIOD GAIN
$T\theta$—VEHICLE PATH TIME CONSTANT
$\dot{\theta}$—PITCH RATE
p—DIFFERENTIAL OPERATOR



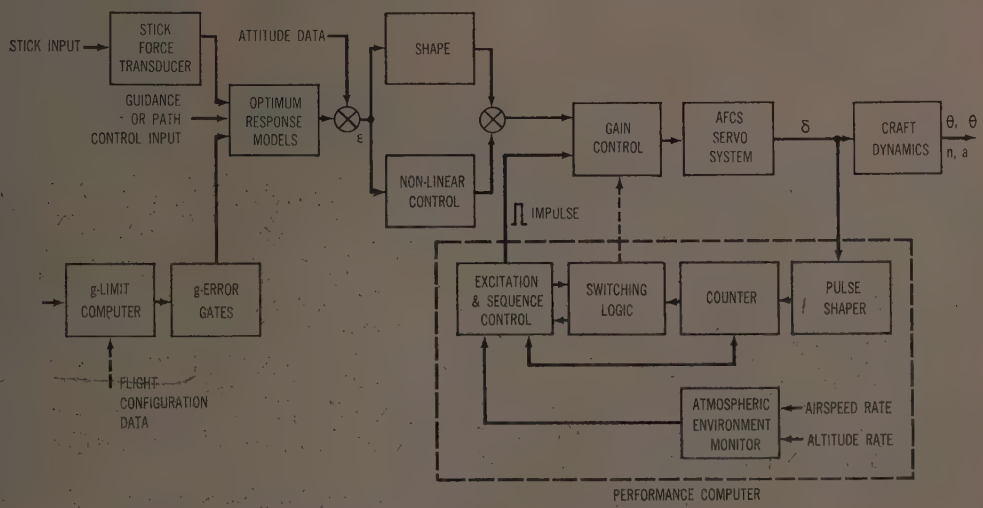
A


$X_i(t)$
$X_o(t)$
D
E
$X_i^*(t-\tau_1)$
$X_i(t-\tau_1)$
$-X_o(t)$
$X_o(t)\ X_i(t-\tau_1)$
$X_o(t)\ X_i(t-\tau_1)=g(\tau_1)$
G
H
$X_i^*(t)$
$X_i^*(t-\tau_2)$
$X_i(t-\tau_2)$
$X_o(t)$
A
B
C
F
(A) BINARY NOISE GENERATOR
(B) SAMPLER
(C) SHIFT REGISTER
(D) 1-BIT STORAGE ELEMENT
(E) AIRCRAFT
(F) RECORDER COMMUTATOR
(G) DIODE GATES
(H) FILTER

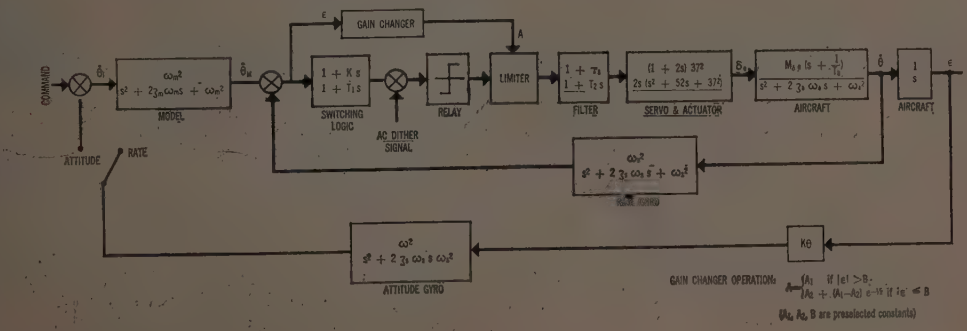
B


AIR DYNAMIC PRESSURE
IAS METER
IAS SIGNAL
POT POSITION SERVO
AIRCRAFT INTERFERENCE FORCES & TORQUES
POT SHAFT POSITION
PITCH ORIENTATIONAL COMMAND SIGNAL
PITCH COMMAND SIGNAL AMP
PITCH ANGULAR VELOCITY COMMAND SIGNAL
PITCH INTEGRATING GYRO
PITCH GYRO SIGNAL
PITCH GYRO AMP
PITCH GYRO AMP SIGNAL
SHAPED POT
ELEVATOR COMMAND SIGNAL
ELEVATOR SERVO SYSTEM
ELEVATOR ANGLE
PITCHING MOMENT
AIRCRAFT
CONTROLLED LINE
PITCH ANGULAR VELOCITY
DAMPING LOOP
PITCH DAMPING SIGNAL
PITCH RATE GYRO
ORIENTATIONAL CONTROL LOOP

C


STICK INPUT
STICK FORCE TRANSDUCER
ATTITUDE DATA
SHAPE
GUIDANCE OR PATH CONTROL INPUT
OPTIMUM RESPONSE MODELS
ε
NON-LINEAR CONTROL
GAIN CONTROL
AFCS SERVO SYSTEM
δ
CRAFT DYNAMICS
θ, θ̇
n, a
IMPULSE
g-LIMIT COMPUTER
g-ERROR GATES
FLIGHT CONFIGURATION DATA
EXCITATION & SEQUENCE CONTROL
SWITCHING LOGIC
COUNTER
PULSE SHAPER
ATMOSPHERIC ENVIRONMENT MONITOR
AIRSPEED RATE
ALTITUDE RATE
PERFORMANCE COMPUTER

D

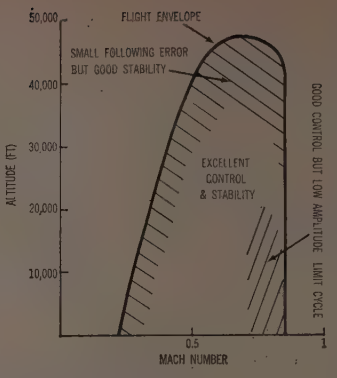

GAIN CHANGER
COMMAND
MODEL
SWITCHING LOGIC
AC DITHER SIGNAL
RELAY
LIMITER
FILTER
SERVO & ACTUATOR
AIRCRAFT
ATTITUDE
RATE
ATTITUDE GYRO
GAIN CHANGER OPERATION:

design digest

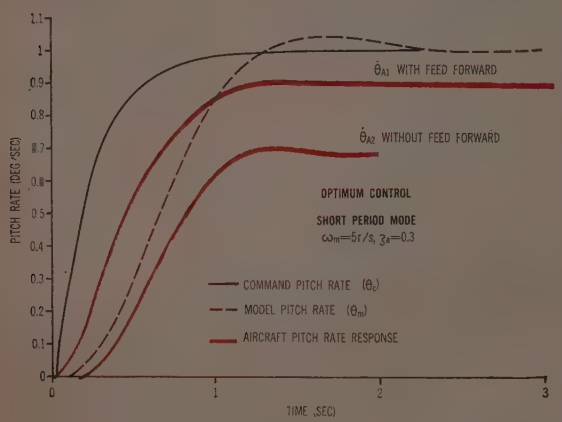
Variational Calculus

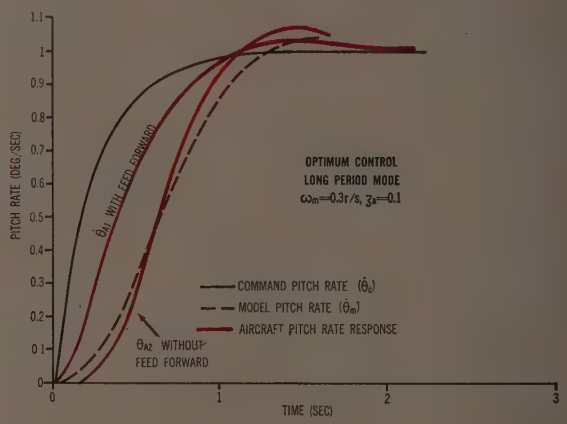
Digital computers have transformed the theory of variational calculus (with its ultra-complex and lengthy integral equations) from a mathematician's whim to a useful tool. One USAF contractor on the adaptive control program, Dodco, Inc., Blawenburg, N. J.—a firm with some five men and two Librascope LGP-30 digital computers—uses the variational technique to calculate optimum flight paths and control criteria and techniques. Applying Euler's equations as bounded by Lagrange's restraints, Dodco is able to make rigid analyses of non-linear systems. Latest indications are that optimum control can limit errors to the threshold sensing limits of the sensors.

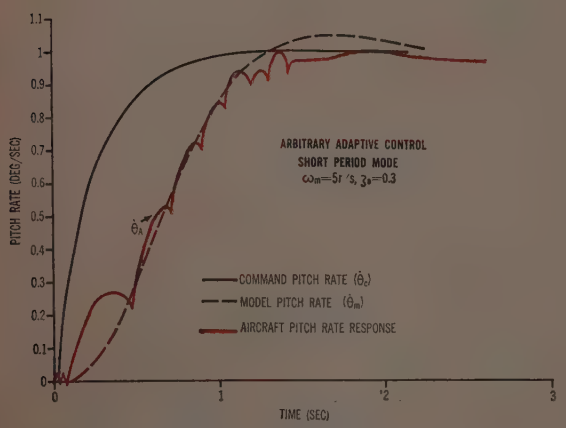
Unlike ordinary differential and integral calculus, which define minimum and maximum points, variational calculus leads to equations that define the optimum paths of all possible combinations of paths.

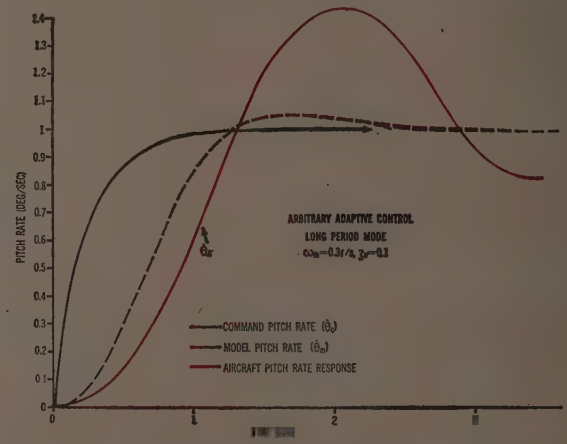


ADAPTIVE FLIGHT TESTS — Flight envelope is based on 19 flights in Lockheed F-94C with Minneapolis-Honeywell's adaptive pitch rate control without gain changer. M-H reports it found dynamic pressure performance invariant and closely resembling that of the model. It also found transient response errors at low dynamic were significant and a low amplitude, high frequency steady state oscillation at high dynamic pressures. Rapid change maneuvers—such as dives, loops, and rolls—didn't degrade system performance, claims M-H. The M-H system to date is the only one with a significant amount of actual flight time (some 60 flights). As yet no adaptive system has been flown in a supersonic vehicle. Test installations in a McDonnell F-101 are in the works.









CONTROL CURVES—Data derived in Dodco's digital computer study of simplified linear "aircraft" equations. Results are plotted for optimum and arbitrary adaptive controllers for long and short period characteristics of the assumed aircraft response. Since the graph at top left was prepared, considerable progress has been made, says Dodco, in handling steady-state errors within the framework of a variational treatment. The graph at top right shows the very rapid rise characteristics possible despite the sluggishness of the controlled element. The arbitrary controller was an early version of M-H's adaptive automatic flight control system.

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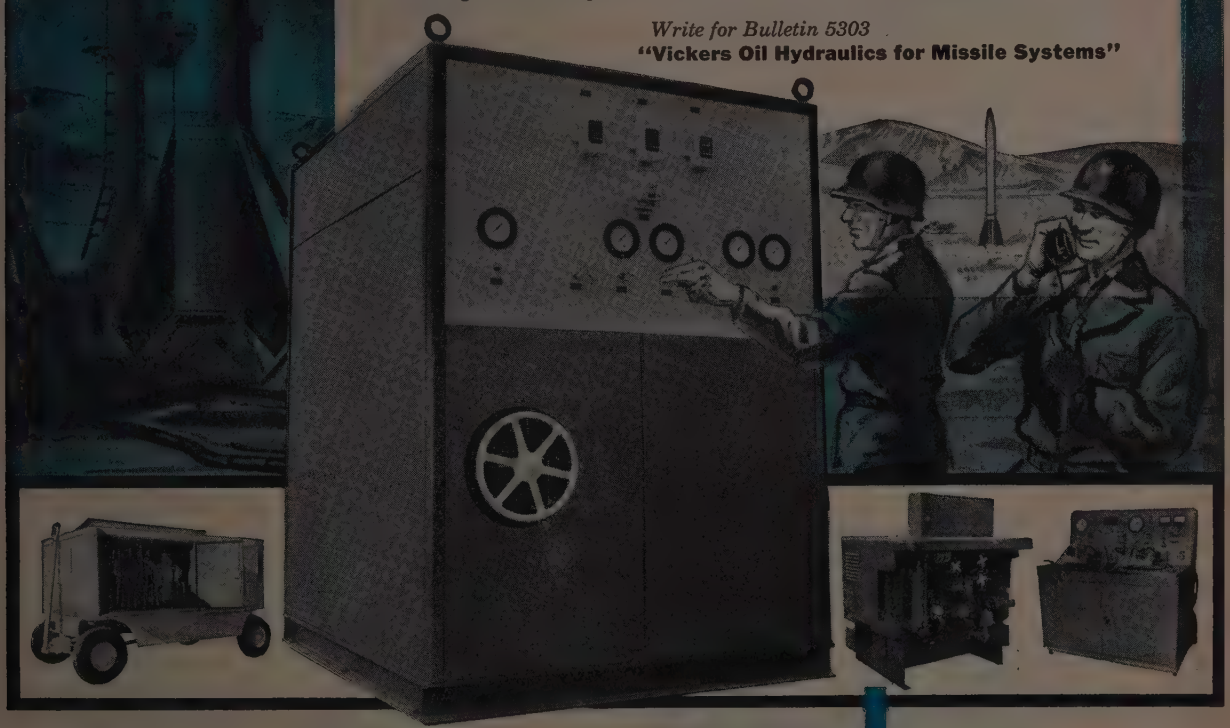

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Missile detection by satellite

This is the first article in a two-part series on the possibilities of adapting recon satellites to the detection of isolated ICBM firings. Based on a detailed study of satellite reconnaissance by a research group at Du Mont Labs,* it analyzes the optical problems posed by field-of-view requirements, detector limits, missile emissivity, and contrast.

THE reconnaissance satellite, because of the very nature of its original mapping mission, offers an excellent opportunity for what might be called "earliest warning" —the detection of the firing of ICBMs anywhere on earth. However, for this application, the designer must overcome the problems posed by the difference between mapping the earth's surface and detecting a firing. Reliable detection of missiles within the burning interval demands that you continually survey an extremely wide area.

Pinpointing a missile firing against the background of the earth is complicated by the total light received from the background, which is relatively large compared with that received from the missile. The following analysis for a photomultiplier detector is based primarily on a comparison of the signal (detected as an ac modulation of the output current) with the noise in the output current resulting from the general background illumination.

We can express the light flux falling on the photocathode from the earth (L_e) as:

(1) $L_e = BA_p/4f^2$ *lumens*,

where B is brightness of the earth (in foot-lamberts); A_p, photocathode area (in square feet); and f, F-number of the optical system. The light flux hitting the photocathode from the missile (L_m) is:

(2) $L_m = CA'_l/R^2$,

where C is the candlepower of the missile reflection, A'_l, the optical system's aperture area (in square feet); and R, the distance to the missile (in feet).

Now, if we assume that the missile's plume has the same spectral distribution as the background light within the spectral response range of the photomultiplier, we find that the resulting currents from the earth (I_e) and from the missile (I_m) at the anode of the photomultiplier are:

(3) $I_e = BGA_p/4f^2$,

(4) $I_m = CGA'_l/R^2$,

where G is the sensitivity of the photomultiplier (in amp/lumen). The mean square shot noise current at the anode of the photomultiplier (i_n^2) can be expressed as:

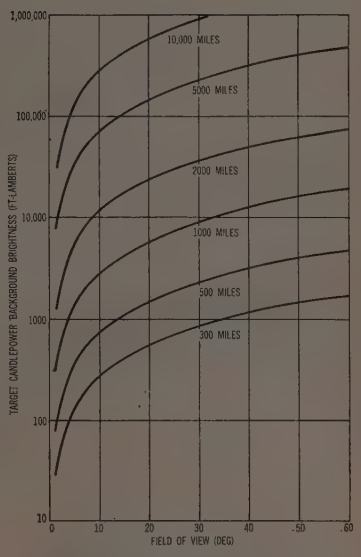
(5) $i_n^2 = 3.2 \times 10^{-19} \times I\Delta F$,

where I is anode current (in amperes) and ΔF is bandwidth of the detection circuit (in cps). The noise current can be given as:

(6) $i_n = 5.65 \times 10^{-10} \times (I\Delta F)^{\frac{1}{2}}$.

Since the missile signal current will be small compared with the back ground current, the total current (I) in *Equation 6* may be replaced by I_e from *Equation 3*, giving:

(7) $i_n = 5.65 \times 10^{-10} (BGA_p\Delta F/4f^2)^{\frac{1}{2}}$.



TARGET-BACKGROUND ratio for various ranges of missile detection at an S/N ratio of 2 and with a system using a 10-cps band-width, a 1.5-in. photocell, and six-inch optics.

If the relationship of signal to noise is to be S/N, then I_n must equal $(S/N)i_n$. It follows that:

(8) $CGA'_l/R^2 = 5.65 \times 10^{-10} (S/N)(BGA_p\Delta F/4f^2)^{\frac{1}{2}}$.

Solving for the required missile candlepower, and collecting constants, we get:

(9) $C = 2.82 \times 10^{-10} R^2 (S/N) [(A_p^{\frac{1}{2}}/A'_l f)(\Delta F/G)^{\frac{1}{2}} B^{\frac{1}{2}}]$,

which shows the effect of various parameters on the detection of a missile of candlepower C against a background with brightness B. We may better understand this effect from:

(10) $A_p^{\frac{1}{2}}/A_l f = 2.26 \tan \phi/2/d_l$,

more on page 160

*Space Reconnaissance Laboratory Research & Development Div., Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.

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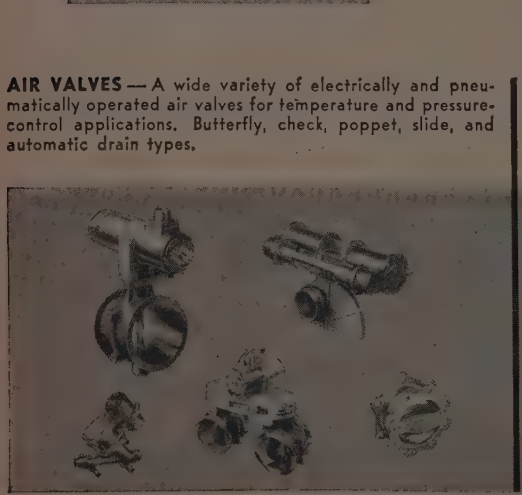

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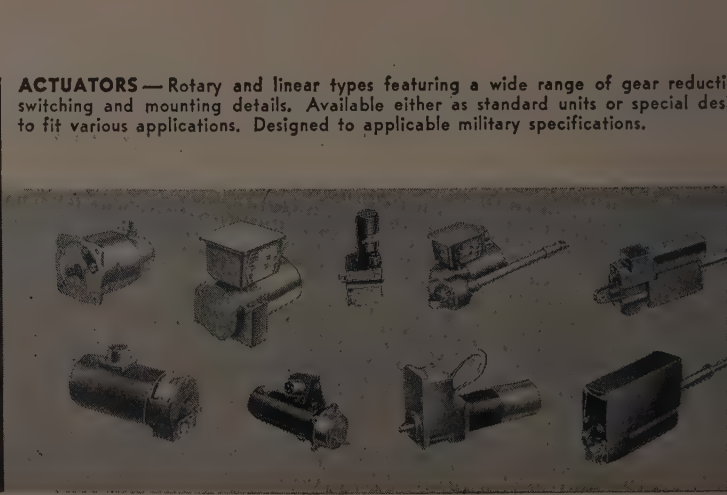

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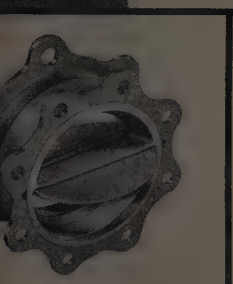

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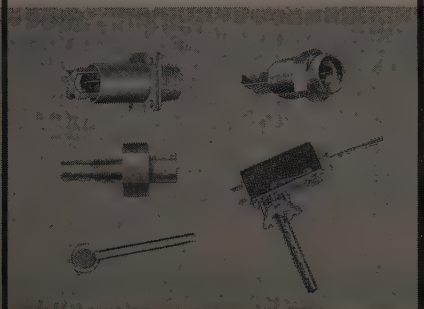
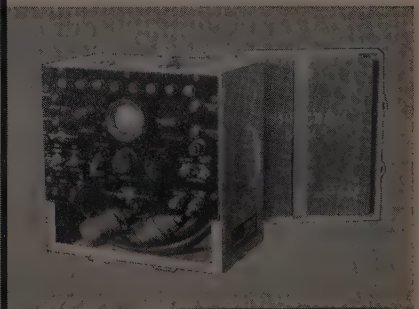


TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.



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where ϕ is the angle of view and d_l is the diamteer of the optical system (in feet). Thus candlepower can be expressed as:

(11) $C = [6.36 \times 10^{-10} R^2 (S/N) \tan\phi/2 (\Delta F)^{\frac{1}{2}}/d_l G^{\frac{1}{2}}] B^{\frac{1}{2}}$

We can see that the detectable candlepower of the missile varies as the square root of the background brightness. Detectability is improved through use of a large aperture optical system, a highly sensitive photomultiplier, and small detection bandwidth and field of view. We see, too, that detectability decreases with the square of the distance between satellite and source.

In practice, you can't select the sensitivity (G) of the photomultiplier, because of the limit on the total of anode current the tube can handle. To find the usable sensitivity for a maximum allowable anode current (I_{max}), we can use *Equation 3*, or:

(12) $G = 4f^2 I_{max}/BA_p$.

If we apply this practical limitation, *Equation 11* becomes:

(13) $C = [3.18 \times 10^{-10} R^2 (S/N) \tan\phi/2 (\Delta F)^{\frac{1}{2}} A_p^{\frac{1}{2}}/d_l f I_{max}^{\frac{1}{2}}] B$

We now have changed the variation of detectable missile candlepower with background brightness from a square-root relation to a linear one. Hence we can form the ratio of detectable candlepower to background brightness as:

(14) $C/B = [3.18 \times 10^{-10} (S/N) (\Delta F)^{\frac{1}{2}} A_p^{\frac{1}{2}}/d_l f I_{max}^{\frac{1}{2}}] R^2 \tan\phi/2$

With the required detection ratio $(S/N = 2)$, $\Delta F = 10$ cps, $I_{max} = 5\text{x}10^{-3}$ amp, A_p==0.01225 sq ft for a 1-5-in. diameter, $d = 0.5$ ft and f=5, *Equation 14* reduces to:

(15) $C/B = 1.26 \times 10^{-9} R^2 \tan\phi/2$.

The *Graph* shows the ratio of missile candlepower to background brightness needed for detection with S/N=2 as a function of the angle of view for various ranges. We may draw two important inferences:

- The missile brightness needed for detection against a given background increases rapidly with the field of view.
- Average terrain may show a brightness of around 500 ft-lamberts, while a bright cloud may attain a brightness of around 10,000 ft-lamberts.

Thus for detection in the visible spectrum against clouds from an altitude of 5000 miles, a missile must be large enough for an emissivity on the order of many millions of candlepower.—End

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Small size: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 1⅞" x 1⅞" x 2¾", weighs 9 oz.

Wide performance range: pumps available have theoretical displacement from .0016 to .0419 cu. in. per revolution — flow from .025 to 2.0 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

Unaffected by extreme environments: rugged, reliable Eastern units take loads to 50g in stride — shrug off temperature differentials to meet MIL specs.

Flexibility, economy: mass-produced components can be teamed into the precise configuration you need. Creatively-engineered custom pumps also available.

Contact Eastern for creative contributions to help you solve your hydraulic pump or power problems. Write for Bulletin 360 — your complete new guide to Eastern aviation products.

Hydraulic power • electronic cooling • refrigeration-type cooling pressurization-dehydration • servo-valve hydraulic systems

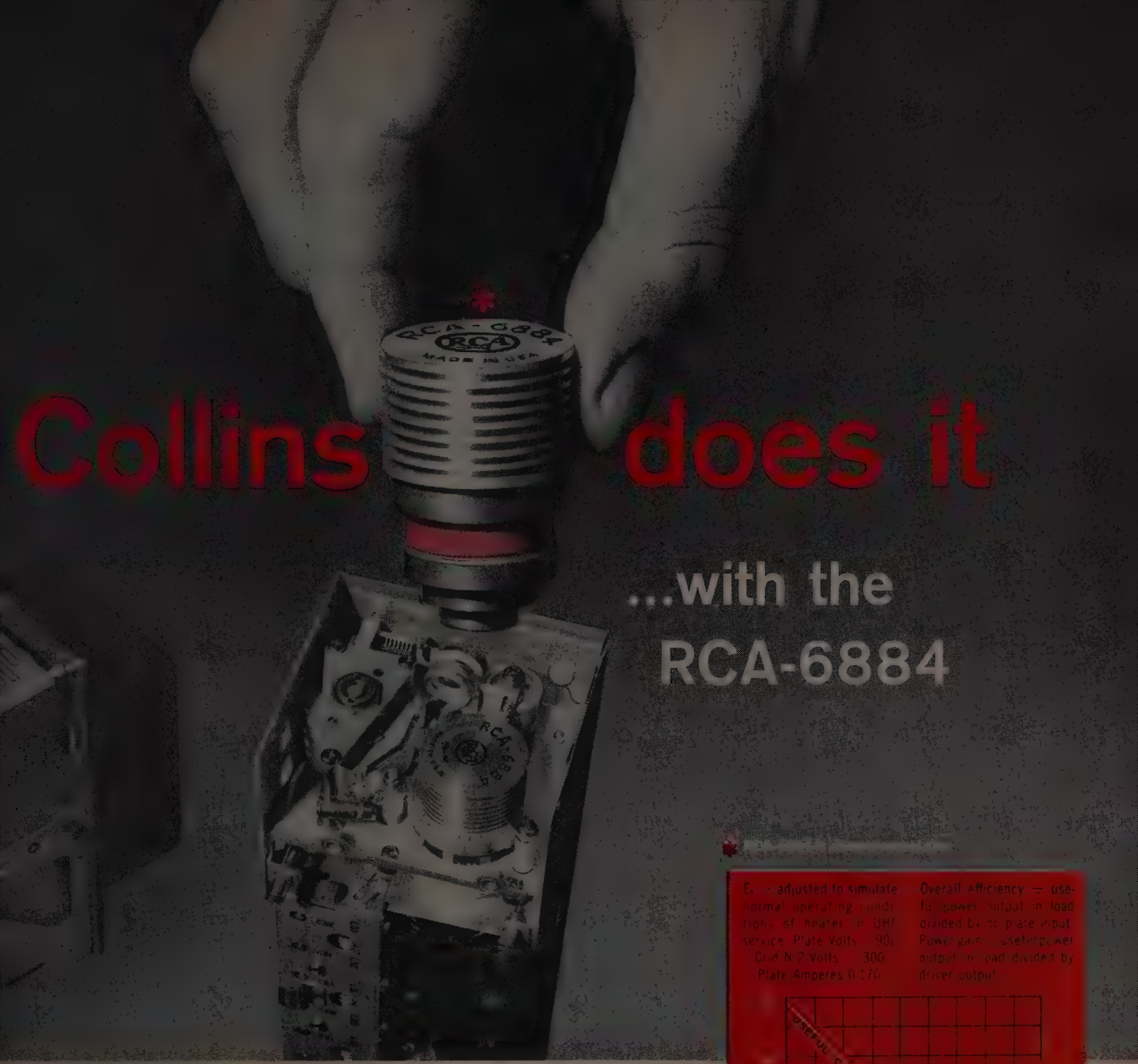
Eastern AVIATION PRODUCTS

EASTERN INDUSTRIES, INC.

100 Skiff Street • Hamden, Conn.

West Coast Branch Office: 1608 Centinela Ave., Inglewood 3, Calif.

Write in No. 345 on Reader Service Card at start of Product Preview Section



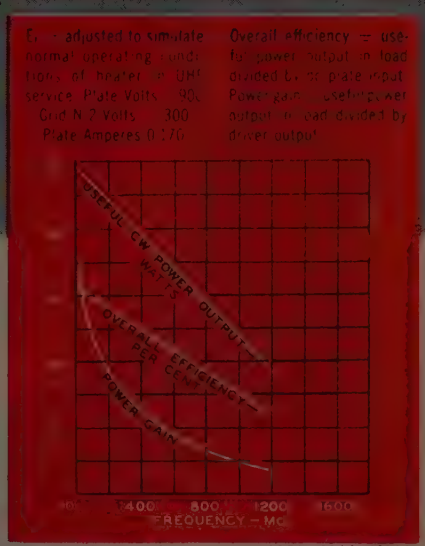
Collins does it

...with the RCA-6884

is a "look-in" at the Collins 17L-7—the irborne VHF transmitter that delivers 25 of power throughout the frequency range to 151.95 Mc. Note the compact arrange- of the power amplifier. See how the 6884 Ceramic-Metal Beam Power Tube itself to efficient and compact circuit .

e are major features we think you ought ow about this beam power tube design: it can deliver up to 40 watts of power at Mc—at a dc plate voltage of only 900 volts driver-stage output of 5 watts (see curves gher power output at the lower frequen- Second, it takes less than 3 cubic inches ace; Third, it utilizes a 26.5 volt, 0.52- re heater; Fourth, it features low-induct- f electrode terminals insulated from each by low-loss, high-strength ceramic bush- ings—a vital factor in any compact VHF and UHF equipment design.

Your RCA Field Representative will be glad to discuss application of the RCA-6884 and its counterpart—the RCA-6816 with 6.3 volt, 2.1-ampere heater—to your transmitter designs. For a technical bulletin on these types, write RCA Commercial Engineering, Section C-59-Q Harrison, N. J.


E, - adjusted to simulate normal operating condi- tions of heater in UHF service. Plate Volts 900 Grid No. 2 Volts 300 Plate Amperes 0.170
Overall efficiency = use- ful power output in load divided by dc plate input. Power gain = useful power output in load divided by driver output.
USEFUL CW POWER OUTPUT - WATTS
OVERALL EFFICIENCY - PER CENT
POWER GAIN
400
800
1200
1600
FREQUENCY - Mc

Typical Performance Characteristics of RCA-6884 & -6816 in Class C Telegraphy or Class C FM Telephony Amplifier Service.

TYPICAL CCS OPERATION OF RCA-6884 AND -6816
RF Power Amplifier, Oscillator—Class C Telegraphy and RF Power Amplifier—Class C FM Telegraphy

	at 400 Mc		at 1200 Mc
DC Plate Voltage	400	900	900 volts
DC Grid-No. 2 Voltage	200	300	300 volts
DC Grid-No. 1 Voltage	—35	—30	—22 volts
DC Plate Current	150	170	170 ma.
DC Grid-No. 2 Current	5	1	1 ma.
DC Grid-No. 1 Current	3	10	4 ma.
Driver Power Output*	3	3	5 watts
Useful Power Output*	23	80	40 watts

*approximate

RCA DISTRICT OFFICES

- 744 Broad Street, Newark 2, N. J.—HUmboldt 5-3900
- Suite 1154, Merchandise Mart Plaza, Chicago 54, Ill. WHitehall 4-2900
- 6355 E. Washington Blvd., Los Angeles 22, Calif. RAymond 3-8361

RCA GOVERNMENT SALES OFFICES

- 415 S. Fifth Street, Harrison, N. J.—HUmboldt 5-3900
- 224 N. Wilkinson Street, Dayton 2, Ohio—BAldwin 6-2366
- 1625 "K" St., N.W., Washington 6, D. C. District 7-1260

RADIO CORPORATION OF AMERICA

Electron Tube Division — **Harrison, N. J**

Visit the RCA Exhibit at the New York IRE Show, Booths 1602-4-6, 1701-3-5-7

synchros
in the popular Size 8 line
are now in production at Daystrom Transicoil.
The new size 8 Synchro Line includes high quality,
top performance transmitters, control transformers,
differentials, and repeaters. Frame size equal to BuOrd
Size 8. Operation: 115V 400 cycles or 26V 400 cycles.
Accuracies to ±5′ are available. Corrosion resistant construc-
tion throughout. Conforms to MIL-E-5272-A.
Write for complete specifications. Be sure to
ask about our 24 Hour Service for rotating components.
Daystrom Transicoil, Division of Daystrom, Inc.,
Worcester, Montgomery County, Pa. Phone JUNO 4-2421.
In Canada: Daystrom, Ltd., 840 Caledonia Rd.,
Toronto 19, Ont. Foreign: Daystrom International
Div., 100 Empire St., Newark 12, N. J.

DAYSTROM TRANSICOIL DIVISION OF DAYSTROM, INC.

Representatives in Canada and Other Foreign Countries

SEE US AT THE I.R.E. SHOW—BOOTH 1808

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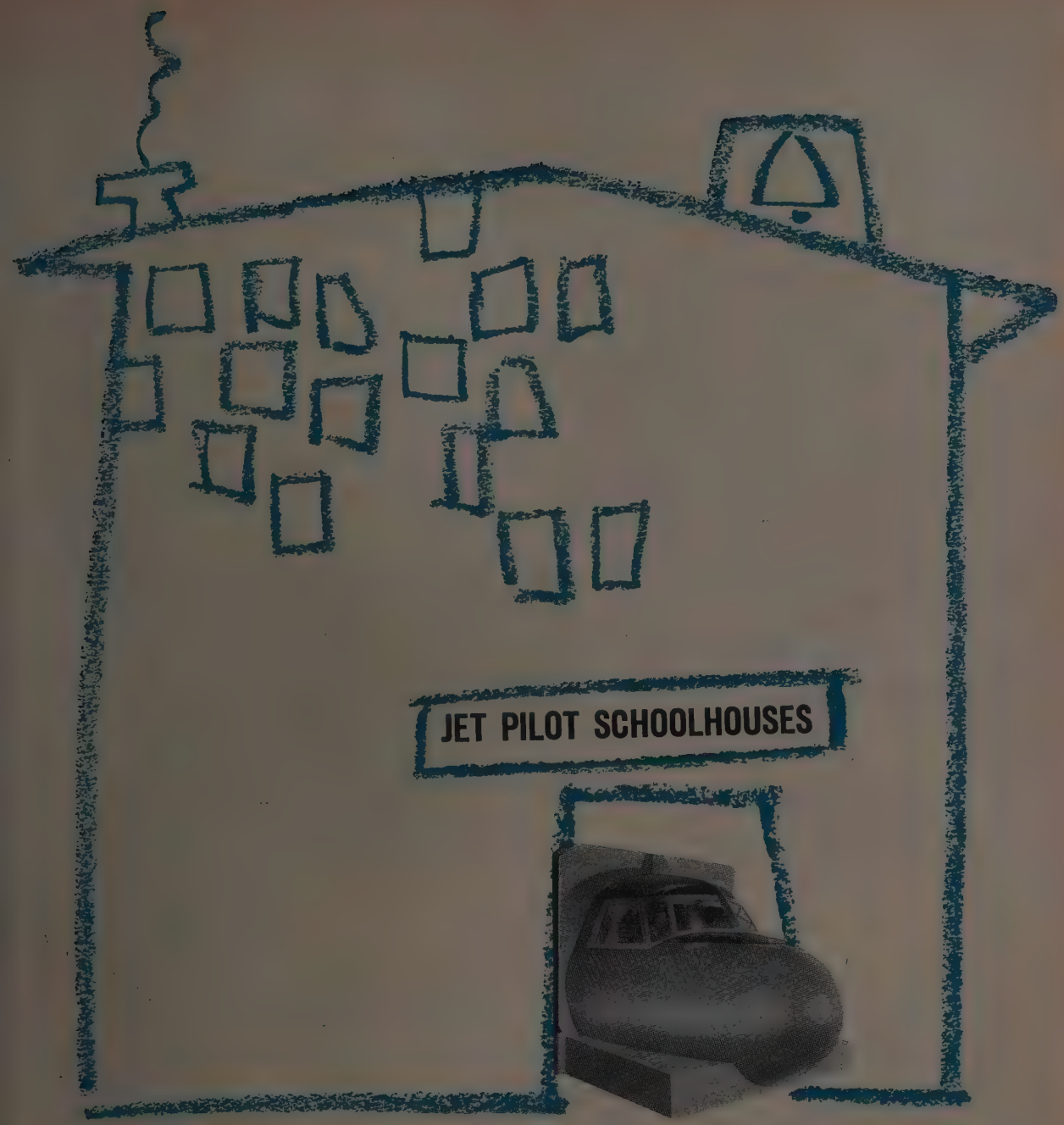

USE MIDWAY INSTRUMENTS FOR TRAINING RELIABILITY

Accuracy is important in Simulator Instruments too. The tough problems thrown at a jet pilot trainee when he's "flying" a flight simulator call for swift, efficient corrective action. His simulator instruments must indicate the problem accurately and reflect instantly and precisely his remedial procedure.

With the high degree of automated electronic flight, characteristic of the new commercial jets, it is all the more important that the simulator is the place where the new jet pilot learns to respect, and live by, his instruments.

ABOUT MIDWAY

EXPERIENCE . . . Midway has designed and produced hundreds of different types of simulator instruments which are helping to train new pilots for the Boeing 707, Convair 880, DC-8, and Lockheed Electra.

FACILITIES . . . Its modern air-conditioned plant, engineers and craftsmen are capable of producing to your particular quantity and design needs . . . from a single prototype unit to a full production run.

*Midway is also uniquely equipped to perform specialized services in engineering design, prototype development, and production of custom precision instruments for other applications.

MIDWAY

MIDWAY AIRCRAFT INSTRUMENT CORPORATION / 185 BERGER STREET / WOOD-RIDGE / NEW JERSEY

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Brush militarized recording

systems are....

READY NOW FOR "2nd GENERATION" SPACE VEHICLES!

When "second generation" space vehicles become operational, the readout of their performance will be monitored by Brush militarized equipment already in existence.

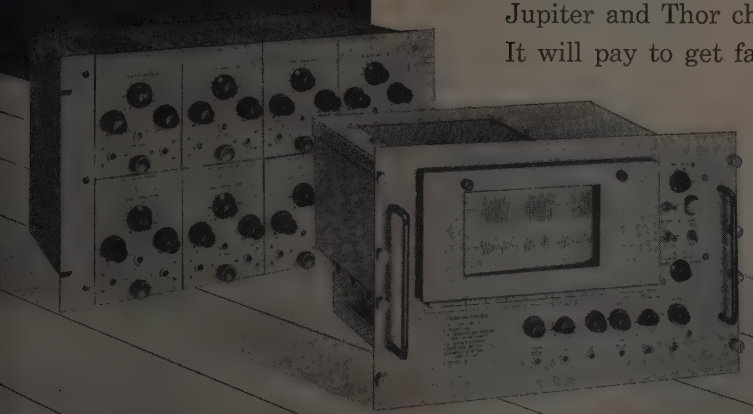
For instance, the 100-Channel Operations Monitor that will record 100 channels of data simultaneously – on a chart 12″ wide! Complex checkouts are simplified.

Or 2- and 6-channel systems (including oscillograph and amplifier)... or the combination Analog and Sequential Recorder.

All equipment complies with Mil. E-16400, Mil. E-4158, Mil. E-4970 and other specifications as required.

For maximum reliability, equipment utilizes fast-response electric writing, proven on critical operational sites such as DEW Line, Jupiter and Thor checkouts.

It will pay to get familiar with this equipment now – before you are confronted with prototype design problems. Brush engineers are available to give you needed details, or write us direct.



brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

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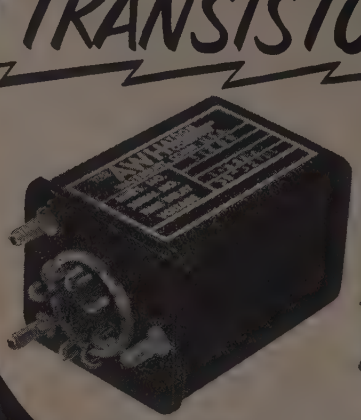
RUGGED RELIABLE

New!

TRANSISTORIZED



MINIATURE ELECTRONIC TIME DELAY RELAYS 31200 SERIES

SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS 31300 SERIES

A. W. HAYDON COMPANY'S

TRANSISTORIZED SUB-MINIATURE ELECTRONIC TIME DELAY RELAYS!

SAVE SPACE AND WEIGHT!

	Miniature Series	Sub-Miniature Series
Cross Section	17/16" x 1 21/32"	3 1/32" x 1 3/16"
Length	2 1/4" long	2" long
Weight	6 ounces	3 ounces
WRITE FOR:	Bulletin AWH TD-503	Bulletin AWH TD-504

TEST-PROVED PERFORMANCE!
High Temperature: 125° C (250° F).
Vibration: 2000 CPS at 15 g.
Contact arrangements up to 4 pole double throw.
Unique transistorized R.C. time constant network.
Time Delays from 50 MS to 120 seconds. Longer Delays available.
Hermetically sealed housings.

MEET REQUIREMENTS OF MIL-E-5272A.

The A.W. HAYDON Company

223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Design and Manufacture of Electro-Mechanical Timing Devices

See us in Booths 2702-2704 at the IRE Show

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electronics scanner

ELECTRONICS MARKET information is sadly lacking. Only a handful of the larger companies have set up adequate staffs to make meaningful analyses out of the mumbo-jumbo cranked out by DOD bureaus and industry associations.

Small companies play it by ear. Most collect what little marketing data there is on a catch-as-catch-can basis. Many companies are forced to base plans for new products on inaccurate data simply because little accurate data is available.

CONFUSION is often created by conflicting electronics figures put out by DOD, Electronic Industries Assn., and Aircraft Industries Assn. EIA's widely publicized "formula" for extracting the electronics dollar out of military missile and aircraft expenditures is nothing more than a very coarse rule of thumb and quite useless for careful analyses.

MILITARY AND INDUSTRY BRASS adds to the confusion by loosely tossing around statistics figures without giving base value. General Jones or Vice President Smith might tell the Association of Retired Bankers that we spent 50 per cent of the total cost of the F-106 for electronics. What he doesn't explain is that R&D money is included in his figure. Or that he means the cost of the F-106 less its powerplant.

MILITARY MARKETS SPECIALIST was recently hired by EIA at the urging of GE, RCA, and others to come up with useful statistics on the space/aero electronics market.

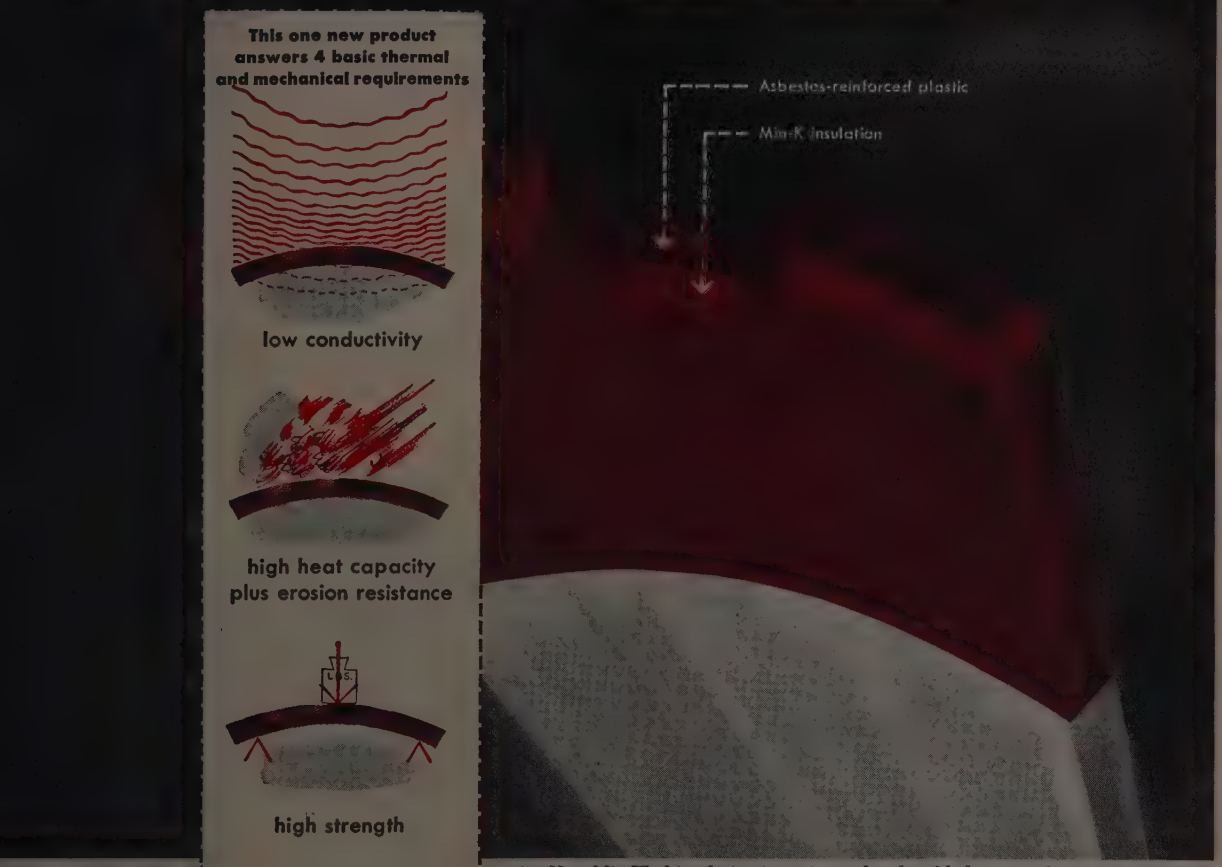
ELECTRONIC COUNTERMEASURES right now represents about a $450 million annual business, according to a survey made by the marketing group of a large electronics company. Airborne ECM and counter-countermeasurers involves some $150 million per year. The survey predicts a slight rise in these figures over the next few years.

Prime example is defensive ECM system for the Boeing B-52. It's

more on page 171

Johns-Manville announces new **MIN-KLAD** Insulation!

This one new product answers 4 basic thermal and mechanical requirements
low conductivity
high heat capacity plus erosion resistance
high strength



New Min-Klad insulation is engineered and molded to your design requirements.

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of MIN-K insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is lower than any other known insulation. Actually lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Write in No. 350 on Reader Service Card at start of Product Preview Section

Unlimited Coupling

Tremendous range of Aeroquip Coupling designs is demonstrated by B. A. Main, Jr., Vice President of Engineering, seated on a 10-inch coupling while holding a miniaturized coupling in his hand. The couplings shown here are only a few of the infinite variety developed by Aeroquip for use with hydraulic fluids, ordinary and exotic fuels, gases, oils, air, liquefied gases, ammonia, nitric acid, ethylene oxide and many other fluids.

Designs!

WITH A WEALTH OF EXPERIENCE PLUS UNMATCHED FACILITIES, AEROQUIP DESIGNS, TESTS AND PRODUCES COUPLINGS TO MEET YOUR SHORT LEAD-TIME REQUIREMENTS

Call on Aeroquip for the solution to your fluid coupling problem. Let s know your requirements on fluid, temperature, pressure, size and pplication, and Aeroquip will recommend, design and produce the oupling that meets your needs . . . and do it FAST!

This is the service that Aeroquip is especially well qualified to rovide for manufacturers of missiles, aircraft and accessories rid components.

Years of experience gained in building millions of couplings nables Aeroquip to approach your problem with complete knowl- dge and understanding. Development facilities include extraor- inary engineering depth plus extensive laboratory, shop and est equipment. Production and quality control facilities are the nest and most modern in the industry.

At Aeroquip, coupling designs and facilities are UNLIMITED!

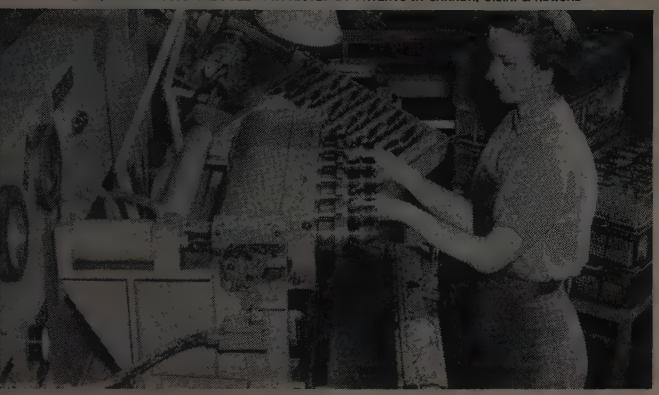
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN
AEROQUIP CORPORATION, WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN CANADA, U.S.A. & ABROAD

Birthplace of many new coupling designs is this modern design section in Aeroquip's development-engineering center at Jackson, Mich. Another engineering staff is maintained at the Western Division in Burbank, Calif., which also produces couplings.

Testing equipment that duplicates conditions ranging from arctic cold to the searing heat generated by jet or rocket engines in flight is included in the development-engineering section, at Jackson, which occupies over 15,000 sq. ft. of floor space.



Aeroquip's high standard of reliability is assured by final proof testing of all couplings. The proof test machine pictured above was specially designed by Aeroquip for maximum dependability and speed. Final testing follows numerous quality control checks during production.

Production facilities in the Jackson plant include this battery of automatic screw machines. Complete manufacturing operations are duplicated in Aeroquip's Western Division plant.

FILL IN AND RETURN THIS COUPON FOR COMPLETE COUPLING INFORMATION SA-3

Aeroquip Corporation, Jackson, Michigan
Please send me further information on Aeroquip Couplings. I am chiefly concerned with the following:

Fluid to be used_____
Temperatures from_____° to_____°.
Pressures from_____psi to_____psi.
Size_____I.D. Operation ☐ manual ☐ remote ☐ other

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

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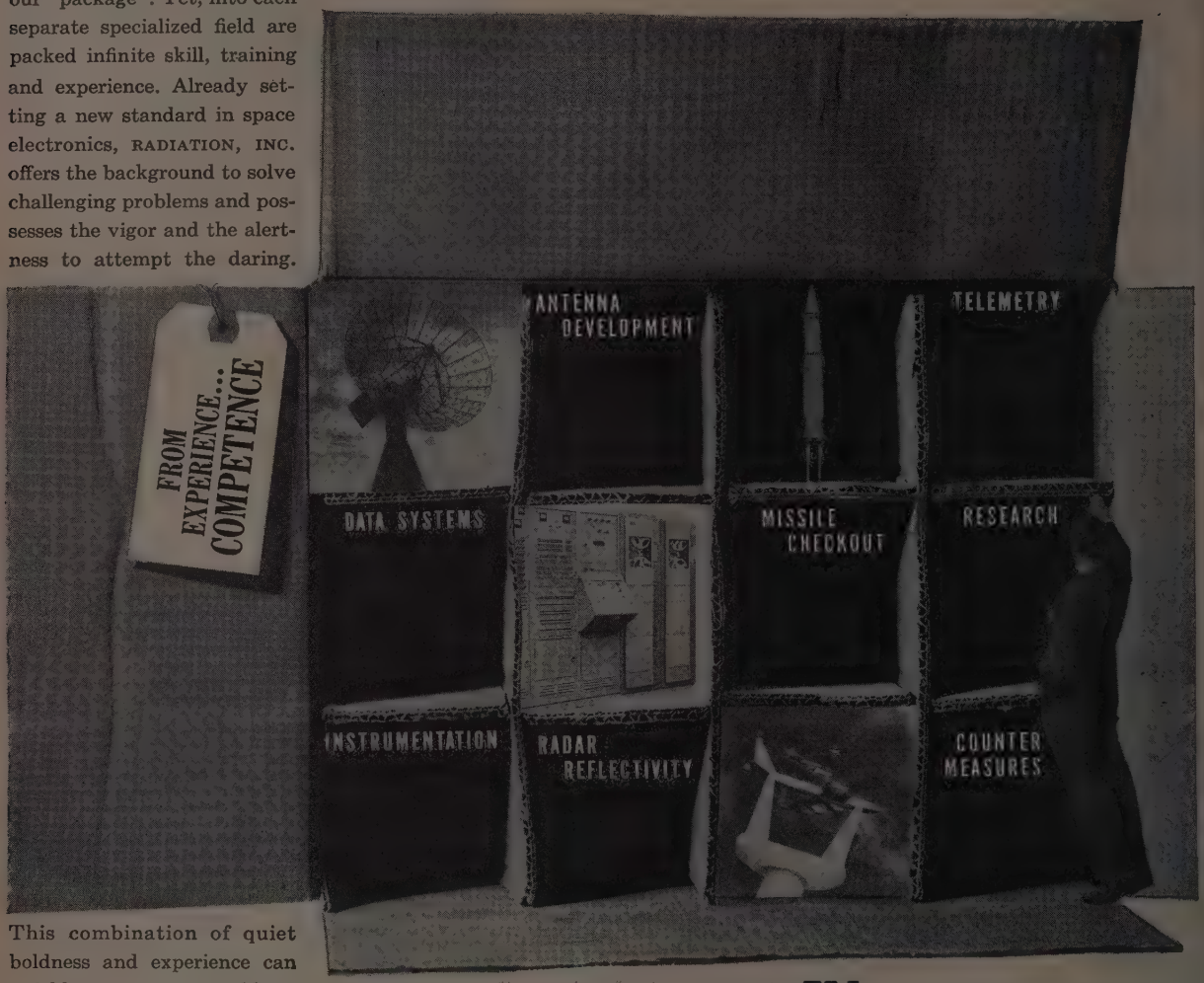
ALL THIS EXPERIENCE

Diverse are the divisions in our "package". Yet, into each separate specialized field are packed infinite skill, training and experience. Already setting a new standard in space electronics, RADIATION, INC. offers the background to solve challenging problems and possesses the vigor and the alertness to attempt the daring.



This combination of quiet boldness and experience can quickly convert *your* problems into assets.

We will be pleased to send you complete literature. Simply specify the field of endeavor that interests you most.

IN ONE COMPLETE PACKAGE

ASTRIONICS
AVIONICS
INSTRUMENTATION

RADIATION INC.

ORLANDO & MELBOURNE, FLORIDA

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estimated this system, which includes decoy missiles and the ALQ-27, will cost as much as a fully equipped B-52—about $5 million.

DOPPLER NAVIGATOR market potential among domestic and foreign airlines is put at some 1700 sensors (at around $15,000 each) and 1200 computers (at $8000-10,000 each) by a leading U. S. Doppler manufacturer. Market among large twin-engine business aircraft is said to be about 1000 sensors and almost as many simple computers.

HIGH PRECISION GYRO price cut is forecast by many manufacturers. Today such a gyro of inertial guidance quality may run from around $10,500 to $15,000 apiece. Manufacturers are shooting for $7000-$8000.

COST OF INERTIAL GUIDANCE in canceled Regulus II missile is estimated at around $405,000 per bird. This is more than the tag on Thor's inertial guidance (also made by AC Spark Plug), which is put at around $200,000 per system.

Most expensive inertial missile guidance system now in the works might be Titan's—at some half million dollars per copy. The first Titan system will probably cost nearly a million.

NON-INERTIAL quality gyros, accelerometers, and platforms of the type used for autopilots, stabilization, directional reference, etc., have been growing into a sizable market. From a $22-25 million volume in '58, this segment of electronics is expected to climb to almost $30 million annually over the next two years.

A Correction

In "Ground-Based Monitor Improves Jet Takeoff Odds" (Feb. '59), the takeoff capability equation was printed incorrectly in the description of the monitor's computer (*p. 139*). The passage should have read:

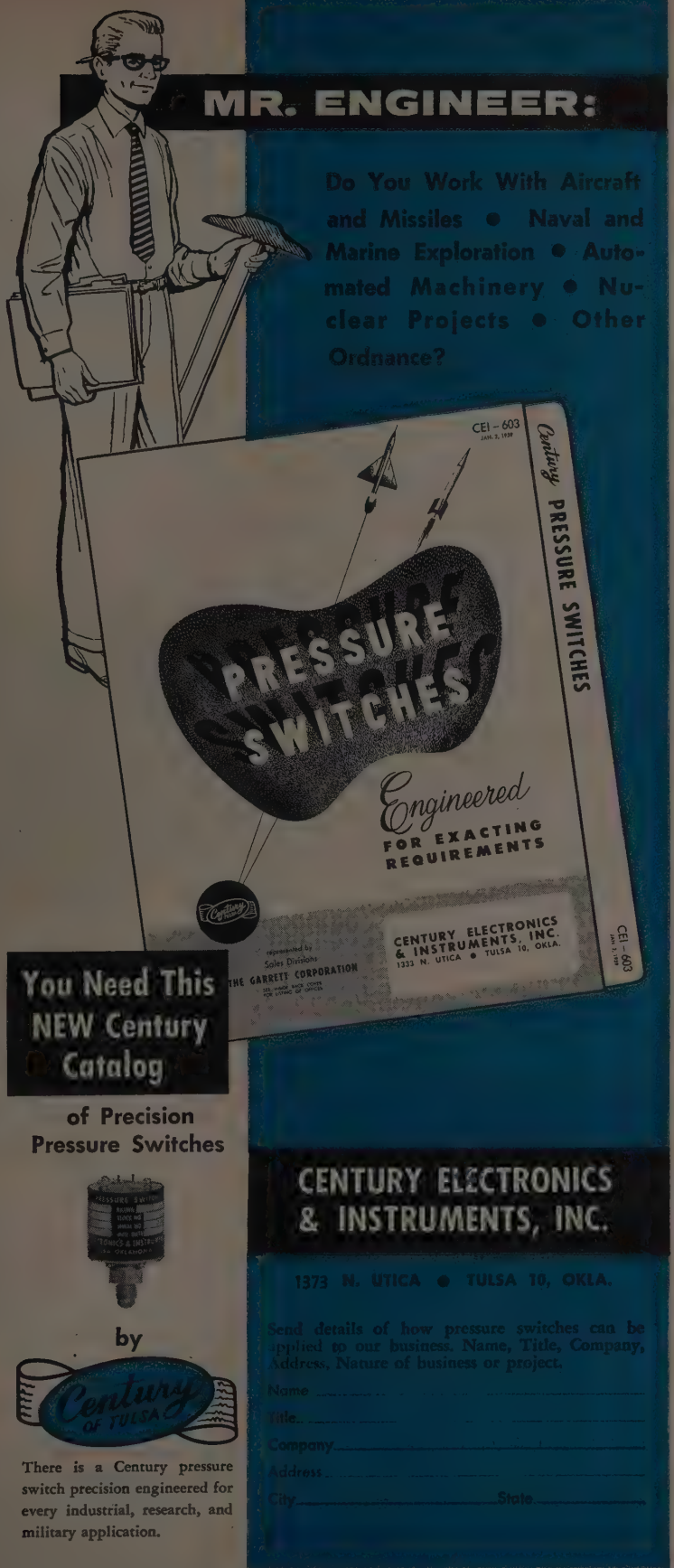
"Takeoff capability is given by:

$$TOC = 0.5\alpha f W^2 - V_e^2/2,$$

where fW^2 is the indicated airspeed required for takeoff. Constructing the complete equation, we get:

$$TOC = 0.5\alpha f W^2 - (V_R + V_w)^2/2 \\ \{-[a\Delta_s - \tfrac{1}{2}A\alpha(\Delta_s)^2,$$

where V_R and V_W are the velocities indicated by, respectively, the Doppler radar and the metro unit."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You Need This NEW Century Catalog
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Send details of how pressure switches can be applied to our business. Name, Title, Company, Address, Nature of business or project.
Name
Title
Company
Address
City State
PRESSURE SWITCHES
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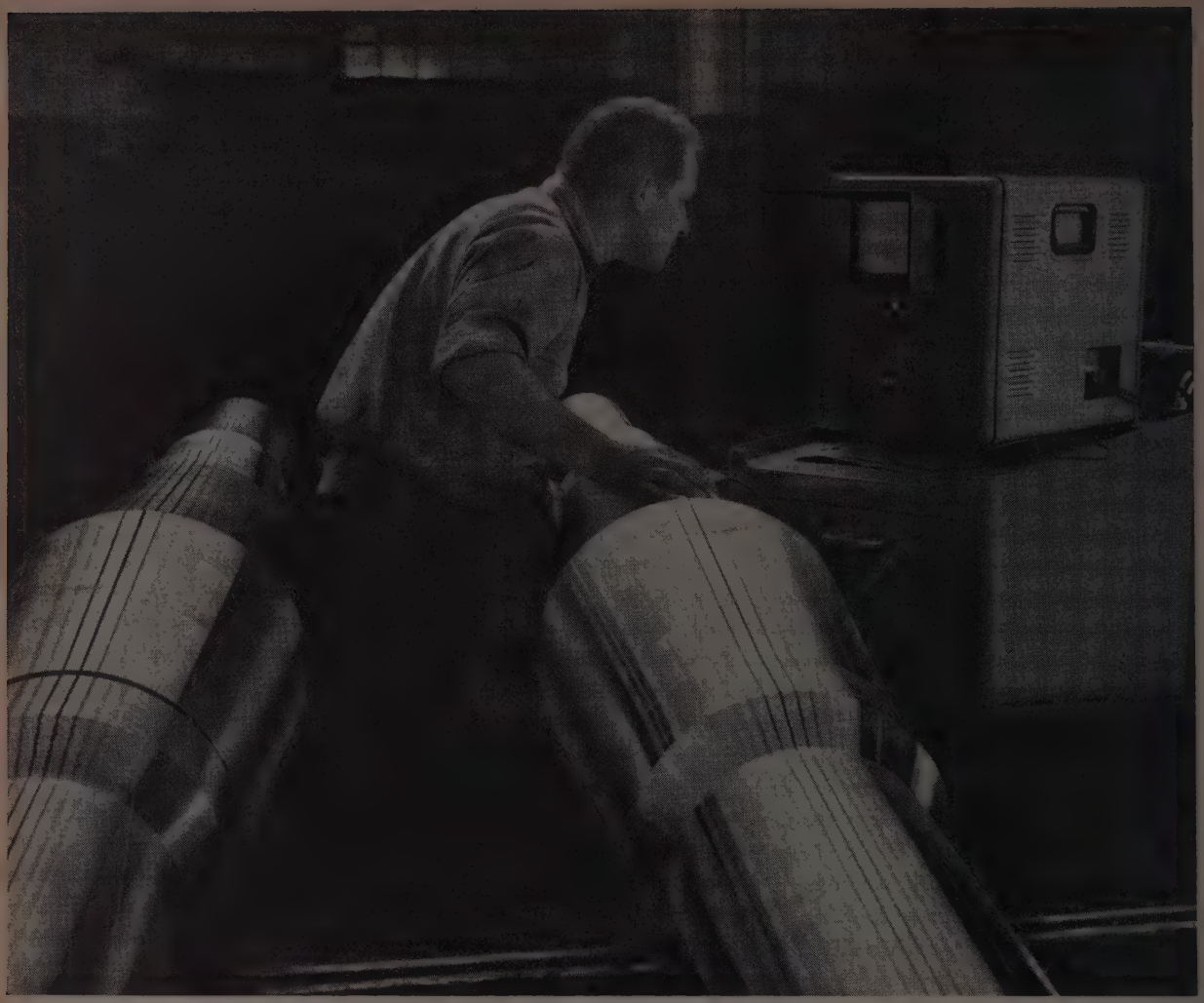

Sonic testing, employing high-frequency sound waves, is one of several methods for detecting internal flaws in steel. Above, an open die-forged shaft is being sonic tested prior to shipment for use in a gyratory crusher.

Quality control—a vital activity at Standard Steel Works

Every conceivable shop and laboratory test required for modern quality control can be performed by Standard's staff of metallurgical technicians. Testing of incoming raw materials for undesirable elements, testing of finished product for minute quantities of gas, ultrasonic, X-ray and microscopic examination, and tests for dimensional integrity are but a few of the routine checks which assure that the finished, delivered product will meet the most rigid specifications. Write Department 6-C for full details.

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

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ELECTRO SNAP

Creators of over 6,000 Precision Switches and Controls

presents . . .

A new panel concept that promises to revolutionize monitoring or control of Missiles and Rockets

the astromatic panel concept

"THE MOST EFFICIENT LINK BETWEEN MIND AND MACHINES"

Consider These Obvious Advantages in Your Designing

- ★ OFFERS INSTANT VISUAL CONTROL WITH EXTREME ACCURACY
- ★ REDUCES HUMAN ERROR TO AN IMPROBABILITY
- ★ PROVIDES SIMPLIFICATION OF THE MOST COMPLEX OPERATION
- ★ ALLOWS REMARKABLE CONSERVATION OF VITAL SPACE
- ★ WITHSTANDS EXTREME LIMITS OF TESTING SPECIFICATIONS
- ★ APPLICATION POSSIBILITIES AS UNLIMITED AS THE IMAGINATION

Study the following specifications with your project in mind . . . .

ASTROMATIC DIVISION
Electrosnap Corporation
4218 West Lake Street, Chicago 24, Illinois

the astromatic panel concept by ELECTROSNAP

Ready now for tomorrow's higher control requirements

This new concept in panel techniques combines the latest advances in scientific, technological and psychological achievements to insure the highest possible degree of efficiency and accuracy in control or monitoring of equipment.

HUMAN FACTOR ENGINEERED

for highest efficiency with extreme accuracy

100% FLUSH PANEL . . . Eliminates protruding hardware . . . unless specified by human engineering requirements. Switching functions may be recessed, flush, or over-flush.

TRI-COLOR LIGHTS . . . Each light module contains 3 separate bulbs and circuits to permit triple indications such as GO, NO-GO and CAUTION signalling.

CONCENTRATED GROUPING OF CONTROLS . . . Multiple function of TRI-LITE controls permits high component density, saving from two to four times space required by ordinary panel. Permits instant visual recognition and action by operator, minimizing time-loss found in larger panels.

VERSATILE SWITCHING . . . The switching and indicating techniques are specifically designed for maximum compatibility with this advanced panel. Momentary, positive feel and alternate action switching is available.

LIMITLESS COLOR COMBINATIONS . . . The unique combination of TRILITES plus multi-color photo printing of panel allows unlimited color guidance, distinctly identifiable even by color blind.

SCHEMATIC DIAGRAMMING . . . Photo color printing of panel surface permits visual schematic diagramming. Increases speed and efficiency of operators and recognition of system indications. Reduces indoctrination period for operator training. Eliminates the written word.

PRECISION ENGINEERED

. . . Meets or exceeds most exacting specifications

SHOCK AND ABUSE TOLERANT . . . Laminated Fiberglas panel resists chipping, shattering, crazing. Coefficient of expansion identical to aluminum sub-assemblies eliminates buckling under stress or extreme cold or heat conditions.

LASTING LEGIBILITY . . . Exclusive process imbues color into Fiberglas . . . resists wear-off of legend and diagramming. Vivid colors actually photoprinted—will not chip or scratch off. Meets all requirements of MIL-P-7788 for Aircraft Cockpit Panel.

QUICK LAMP REPLACEMENT . . . Front panel hinged for quick access to components below, permitting 10-second bulb change if necessary.

EASY TO ALTER . . . During prototyping legend and schematic diagramming can be easily changed to visualize any new findings. Components under panel may be relocated.

VERSATILITY OF DESIGN . . . The module concept of construction makes the Astromatic panel technique extremely versatile. WHATEVER ACTION YOU DESIRE TO VISUALIZE, ASTROMATIC CAN SUBMIT A PANEL DESIGN TO SURPASS YOUR EXPECTATIONS.

MAIL COUPON BELOW FOR ADDITIONAL TECHNICAL INFORMATION . . . OR

Astromatic Division, Electrosnap Corporation
4218 W. Lake Street, Chicago 24, Illinois

Gentlemen: ☐ Have your Design Engineer call for an appointment.
☐ Please count me in on any Symposium held in my area.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

ASTROMATIC DIVISION
Electrosnap Corporation
4218 W. Lake Street, Chicago 24, Illinois
VAn Buren 6-3100, TWX CG-1400

space/aeronautics

CONFIDENTIAL

March 1959
(good until 5/15/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(**1**) Tear out this page.

(**2**) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(**3**) Turn to the back page of this Form and answer the questions on it.

(**4**) Mail this form (in a stamped envelope) to:

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205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ Aerojet General Corp.	182	☐ Martin Co.; Denver Div.	104
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OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention **SPACE/AERONAUTICS** in your application.

space/aeronautics

CONFIDENTIAL

March 1959
(good until 5/15/59)

Employment Inquiry Form

Please type or print (with pencil) (NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.) : _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.) : _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

It's great to be proud of the place you work

A MAN misses a lot if his job means only a paycheck. He ought to be excited about the work he's doing. He ought to feel proud of his company—of its past achievements, its current projects, its future.

That's the way our engineers and scientists feel at Autonetics. They're young men. Most of them got their BS since 1948. In ten memorable years they have made their company a leader in *electronics* and *electromechanics*.

Today there is room for engineers and scientists who want to share the unusual creative problems that lie ahead—in inertial navigation, digital computers, armament control, flight control, and a host of special military and commercial products.

If you'd like to join Autonetics, please send your resume to Mr. D. C. Benning, 9150 East Imperial Highway, Downey, California.

Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California

Among the achievements of Autonetics' young men: the first successful airborne all-inertial navigation system . . . first navigation system accurate enough to guide the USS Nautilus and Skate on their historic voyages beneath Arctic ice . . . first successful automatic star tracking by an inertial navigation system during daylight flight . . . first completely maneuverable, inertially stabilized gyro platform . . . first successful completely automatic landing system for supersonic missiles and aircraft . . . first transistorized portable digital computer with "big computer" capabilities.

Check Employment Inquiry Form on Page 175

ENGINEERS–SCIENTISTS

Engineers and Scientists at Republic Aviation—with a turn for dry professional humor—say that they're asked to solve every problem of upper atmosphere and space flight with the factor

$$\sqrt{1-\frac{v^2}{c^2}}$$

This human application of the relativistic theory of space-time relationships is predicated on the conviction that the creative content of technological thinking can be immeasurably expanded and enriched—given a propitious environment.

That the environment at Republic *is* propitious, is evident from the results.

Engineers and scientists like it. They thrive on it. Technical ideas of a "revolutionary" character—rather than "evolutionary"—are appearing at a rate that exceeds the norm of even 5 years ago.

In every professional area—research, development, experimental engineering—*the goal is the same:*

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in terms of technological progress

▶ *in exotic propulsion systems for space operation—plasma propulsion...advanced nuclear power applications...*

▶ *in integrated electronic systems for flight vehicles to operate at every altitude*

▶ *in supersonic and hypersonic weapons systems, both manned and unmanned*

For an invigorating environment, where new ideas flourish, look at the range of opportunities at Republic

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THERMO, AERODYNAMICS
Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Airplane/Missile Performance • Air Load and Aeroelasticity • Stability and Controls • Flutter & Vibration • Vehicle Dynamics & System Designs • High Altitude Atmosphere Physics • Re-entry Heat Transfer • Hydromagnetics • Ground Support Equipment

PLASMA PROPULSION
Plasma Physics • Gaseous Electronics • Hypersonics and Shock Phenomena • Hydromagnetics • Physical Chemistry • Combustion and Detonation • Instrumentation • High Power Pulse Electronics

NUCLEAR PROPULSION & RADIATION PHENOMENA
Nuclear Weapons Effects • Radiation Environment in Space • Nuclear Power & Propulsion Applications • Nuclear Radiation Laboratories

A new $14,000,000 Research Center—to be completed this year—is part of Republic's far-ranging R&D programs aimed at major state-of-the-art breakthroughs in every flight regime and environment.

Send resume in complete confidence to:
Mr. George R. Hickman, Engineering Employment Mgr., Dept. 6C

REPUBLIC AVIATION
Farmingdale, Long Island, New York

ENGINEERS:

The kind of work you want in MISSILE ELECTRONICS

The kind of life you want for your family

GET *BOTH* AT

BENDIX YORK

ELECTRONIC ENGINEERS

PHYSICISTS

MECHANICAL ENGINEERS

• Challenging opportunities in CIRCUIT DESIGN, PULSE & VIDEO CIRCUITRY, MICROWAVE, DIGITAL & ANALOG COMPUTERS, SEMI-CONDUCTORS, COMPONENT AND CIRCUIT RELIABILITY.

Interesting work on FUZING TECHNIQUES, BEACONS, SIMULATORS, SPECIAL TEST EQUIPMENT.

• Bendix York offers you the opportunity for rapid professional growth and advancement. Enjoy the small-company atmosphere of an expanding division of one of America's largest engineering and manufacturing corporations . . . And the way of life in and around York, Pennsylvania is ideal for the entire family. It combines the charm and grace of rural living with the many advantages of a dynamic and progressive community.

Let us hear from you!
Address replies to: Dept. S
PROFESSIONAL EMPLOYMENT

Bendix
AVIATION CORPORATION
York Division
York, Pennsylvania
"The way of work for you, the way of life for your family!"

You can explore new areas at IBM in

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LMNO
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STUV
WXY
Z&$?!:;

COMMUNICATIONS:

10
29
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56

Creative people at IBM are hard at work on a problem that has vexed man since the dawn of history — communication with his fellow beings. One group of scientists and engineers, for instance, is working on multiplexing techniques to channel data. This data has to be made available at desired times and places. Another group is developing computer systems that will control complete warehousing or industrial operations. Careers in data communications are available at IBM in these areas: circuit design & research, computer analysis & design, cryogenics, industrial controls, inertial guidance, information theory, mathematics, optics, semi-conductor design, and solid state.

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Qualifications: B.S., M.S., or Ph.D. in Electrical or Mechanical Engineering, Physics, or Mathematics — plus proven ability to assume a high degree of technical responsibility in your sphere of interest.

For details, write, outlining background and interests, to:

Mr. R. E. Rodgers, Dept. 522C
IBM Corporation
590 Madison Avenue
New York 22, N. Y.

INTERNATIONAL BUSINESS MACHINES CORPORATION

IBM®

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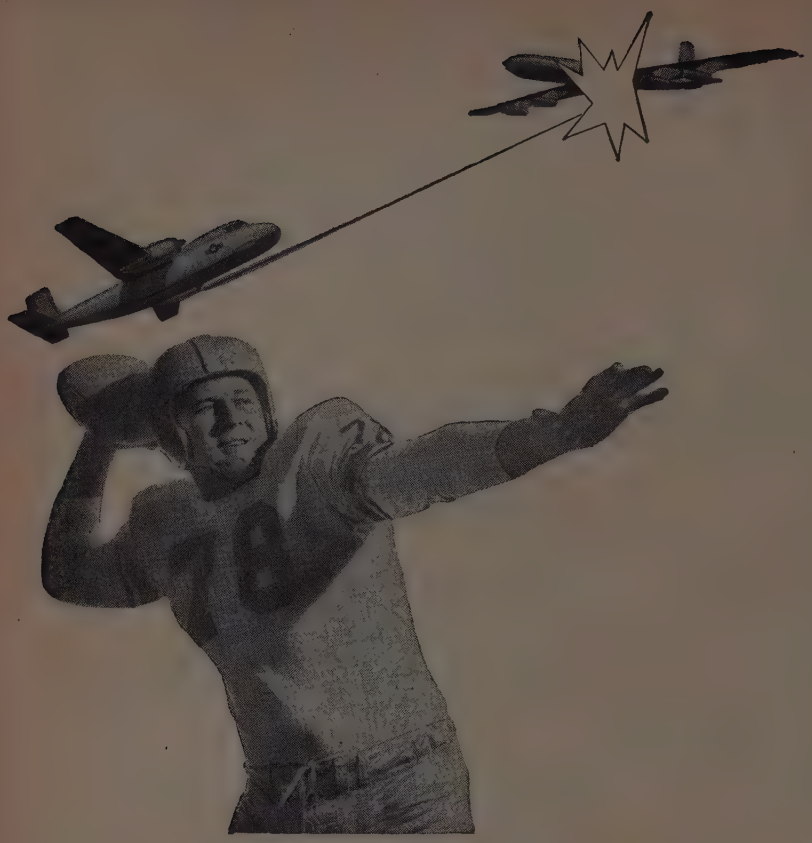

QUARTERBACKING THE EAGLE PROJECT

Bendix Aviation Corporation will be prime contractor for the Eagle missile—and Bendix Systems Division will quarterback the project.

Latest in a series of important defense projects to be assigned Bendix Systems, the Eagle will be a long-range, air-to-air missile designed for fleet air defense and interception missions.

Responsible for systems management and engineering in connection with the project, Bendix Systems Division will also direct the development of the Eagle missile, electronic guidance, and fire control equipment in the launching aircraft.

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Located adjacent to the Engineering campus of the University of Michigan, Bendix Systems Division offers the better man an outstanding opportunity to join an organization with full facilities for encouraging his finest work. Ann Arbor is a wonderful place to live and raise a family, a town which combines life in a college community with the nearby advantages of a large city.

If you are interested and qualified in weapons system planning, research and development, you are invited to write to Bendix Systems Division, Dept. J-3, Ann Arbor, Michigan.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION

Check Employment Inquiry Form on Page 175

Flight Data and Control Engineers

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. **ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS** A wide choice of opportunities exists for creative R & D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servomechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

2. **SERVO-MECHANISMS AND ELECTRO-MAGNETICS** Requires engineers with experience or academic training in the advanced design, development and application of magamp inductors and transformers.

3. **FLIGHT INSTRUMENTS AND TRANSDUCERS**

   1) **DESIGN ANALYSIS** Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

   2) **DEVELOPMENT** Requires engineers skilled with the analysis and synthesis of dynamic systems including design of miniature mechanisms in which low friction freedom from vibration effects and compensation of thermo expansion are important.

4. **PROPOSAL AND QUALTEST ENGINEER** For specification review, proposal and qualtest analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

Forward resume to:
Mr. G. D. Bradley

THE GARRETT CORPORATION
9851 S. Sepulveda Blvd.
Los Angeles 45, Calif.

DIVISIONS:
AiResearch Manufacturing—Los Angeles
AiResearch Manufacturing—Phoenix
AiResearch Industrial
Air Cruisers—Airsupply
Aero Engineering
AiResearch Aviation Service

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Check Employment Inquiry Form on Page 175➔

the Pioneer in space

To send the U. S. Pioneer more than 60,000 miles into interplanetary space, Space Technology Laboratories in seven months designed, developed, assembled, and sted an 88-foot combination of three integrated stages with a payload incorporating 36 separate ignition systems. 's Astrovehicles Laboratory focused on the payload itself and the sensitively related problems of propulsion, weight, id stability. These are in addition to the overall complexities of the structural configuration.

Pioneer, setting new apogees in science and missilery, pifies the achievements STL is making in the advancement of space technology. Those who are able to contribute to and benefit from these developments are invited to consider joining our staff.

Space Technology Laboratories

Space Technology Laboratories, Inc.
5730 Arbor Vitae Street, Los Angeles 45, California

AEROJET...
for engineering careers

STRESS ANALYSTS

1. Experience and/or training in *analytical* stress computations, with emphasis on structural and pressure vessel applications. B.S. required; graduate work desirable.

2. Experience and/or training in *experimental* stress analysis. Familiarity with advanced experimental techniques and expedient methods of stress analysis. B.S. required; graduate work desirable.

GAS DYNAMICIST

M.S. or Ph.D. in engineering, physics or applied mechanics. Five to ten years' experience in analytical and experimental work in the fields of boundary layer studies, supersonic and hypersonic flows, or application of non-ideal-gas theories.

AERODYNAMICIST

M.S. or Ph.D. in aeronautical or mechanical engineering or applied mechanics. Five to ten years' experience in the field of advanced aerothermodynamics, missile aerodynamics, heat transfer in rockets, missiles, etc.

MISSILE SYSTEMS ANALYST

B.S., M.S. or Ph.D. in engineering, physics or applied mechanics. Five to ten years' experience in analysis and evaluation of interactions between propellant systems and other missile components. Capable of developing optimum vehicle configurations from the standpoint of the propulsion system.

U.S. Citizenship Required

Resumes cordially invited. Write:

E. P. JAMES
AEROJET-GENERAL CORPORATION
P.O. BOX 1947
SACRAMENTO, CALIFORNIA

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COME AHEAD WITH US IN '59

• At the General Electric Jet Engine Department, men with proven ability advance rapidly.

About one out of every two of our engineers was promoted during the past year.

We have doubled our engineering staff since 1955, and now new contracts, new expansion, make it possible for us to offer career opportunities to engineer specialists in a number of fields listed below.

The problems we work on are not simple. They'll tax your engineering skill over long periods of time. But you'll be working in a climate of mental vigor with other top-flight engineers under supervision quick to recognize professional ability, and quick to reward it.

We need young engineers, and we need older, more experienced engineers. You must be a U. S. citizen, and you must have an Engineering Degree. Opportunities exist in the following fields:

ENGINE RELIABILITY . . . AERODYNAMIC DESIGN . . . ELECTRICAL CONTROLS DESIGN . . . ADVANCED ENGINE PERFORMANCE ANALYSIS . . . ENGINE FLIGHT TEST . . . CONTROL COMPONENT DESIGN . . . TEST INSTRUMENTATION . . . ENGINE STATIC PARTS DESIGN . . . and many others.

Send your resume—or, for more information, write or phone:

Mark Peters, General Electric Co.
Aircraft Gas Turbine Div. SA-3
Cincinnati 15, Ohio
Phone POplar 1-4100, Ext. 2181

Collect long distance calls will be accepted any weekday 9a.m.-4p.m.

GENERAL ELECTRIC

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name your sport

Whatever your sport, you'll find it in abundance in Florida and you can enjoy an interesting career to boot with fast-growing Radiation, Inc. The climate here is ideal for outdoor sports the year around.

We have many openings for challenging and rewarding work in electronic design and development. Radiation is well known in DATA PROCESSING, TELEMETRY, ANTENNAS, INSTRUMENTATION, and other areas of MISSILE ELECTRONICS. Our stable growth indicates a secure future with professional advancement for qualified electronic engineers with ideas and energy.

Write today for complete details on opportunities available.

Technical Personnel Dept. 42

RADIATION, Inc.
MELBOURNE, FLORIDA

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IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

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Man-Machine Relationships a Growing Field for Operations Research

Mathematicians, Physicists and Engineers with experience or strong interest in Operations Research on large-scale automated systems will be interested in the major expansion program at System Development Corporation.

SDC's projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships. SDC activities constitute one of the largest Operations Research efforts in the history of this growing field.

Senior positions are among those open. Areas of activity include: Mathematics, Systems Analysis, Forecasts, Cost Analysis, Operational Gaming, Design Analysis, Performance Evaluation.

Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the SDC Operations Research Group. Address System Development Corporation, 2424 Colorado Avenue, Santa Monica, California.

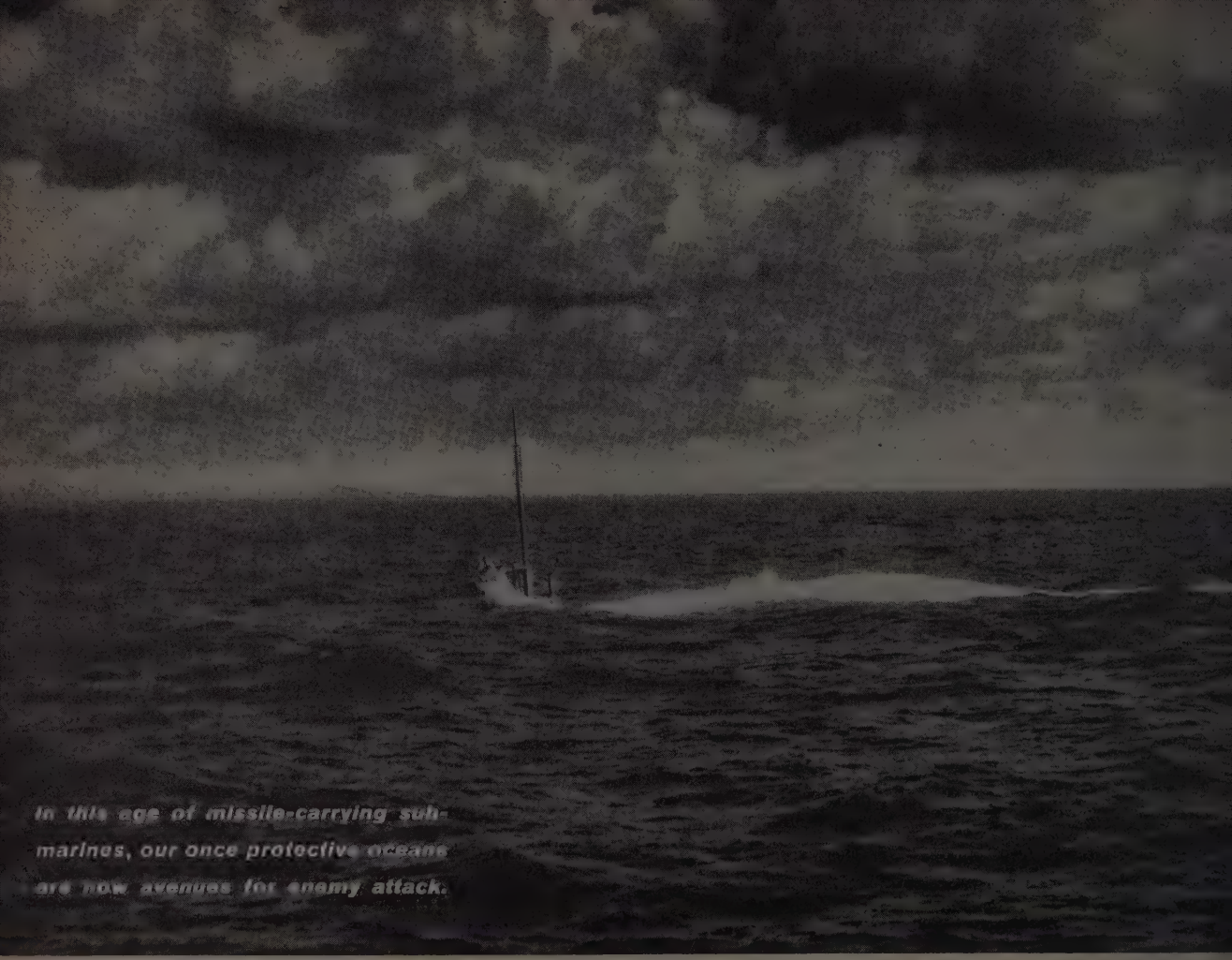
"Method for First-Stage Evaluation of Complex Man-Machine Systems" *A paper by Mr. I. M. Garfunkel and Dr. John E. Walsh of SDC's Operations Research Group is available upon request. Address inquiries to the authors.*

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California

11-65B



circuit development — system planning engineers...

help nab hit-and-run divers

Missile-packing subs able to "torpedo" Indianapolis from either ocean pose a sinister threat... call for even higher levels of detection sensitivity as well as totally new sub-hunting methods. Apparatus division of Texas Instruments has thousands of airborne submarine detector systems in the fleets of the world, but now is expanding its efforts to outstrip the new capabilities of the new generation of submersibles. Other active projects in this division include missile and space electronics, early warning, reconnaissance, airways control, and attack control. Any program you choose will be amply supported by the latest facilities and implemented by TI's ability to create basic components or complete systems.

TI's brisk, steady growth (18-fold over the past decade to a current $91-million volume) creates corresponding needs for all levels of talent. Engineers, physicists... *choose your design or production future* —

PROGRAMS: advanced military systems studies — airborne early warning — airways control — antisubmarine warfare — attack-bomb navigation systems — countermeasures — engine instrumentation — missile systems — portable ground equipment — reconnaissance — space electronics

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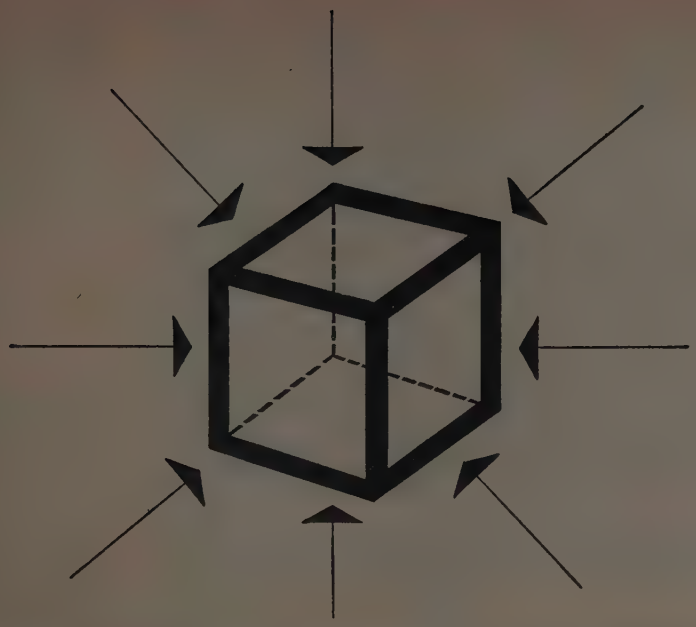
come and grow with us...

Hitch your wagon to the Lone Star... work at a plant within the city but away from downtown traffic... live within minutes of your work or your play — year-around recreational, amusement and cultural activities. Please contact —

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

Mr. John Pinkston Dept. 310
apparatus division



YOU MAY BE JUST THE MAN TO HELP BURROUGHS SQUEEZE A MILLION TRANSISTORS INTO A CUBIC INCH

OR EXPLORE FIELDS LIKE THESE:

- Statistical approaches to physiological processes
- Electro-chemical phenomena
- Radiation effects
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- Magneto hydro-dynamics
- Electro-luminescence
- Cryogenics
- Superconductivity
- Semi-conductors
- And a lot of others

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We need men who can help us put the functional equivalent of a million transistors into a cubic inch of material. Or men who can help us produce equally advanced results in fields like those mentioned at the left.

Men who can thrive on working without strait jackets.

Men who can get the most out of our heavily budgeted research facilities.

Men who can welcome the security of our *cohesive* research programs. How cohesive? Because their common aim is to improve information processing for both commercial and military use. How do the programs offer security? Because their cohesiveness allows you to shift readily from one to another without learning a new technology.

We want men whose creativity will help us double our $300 million yearly sales rate fast—and then redouble it even faster.

Men who are frankly interested in increased responsibility. In swift promotion in careers that offer a wide choice of location. And, yes, in money.

Are you as outstanding as these opportunities? Then outline your education and experience as briefly or fully as you wish, name the field you'd like to help us explore, and get that information to A. L. Suzio, Administrator, Corporate Placement Services, Dept. 105, Burroughs Corporation, Detroit 32, Mich.

Burroughs

Burroughs Corporation

"NEW DIMENSIONS / IN ELECTRONICS AND DATA PROCESSING SYSTEMS"

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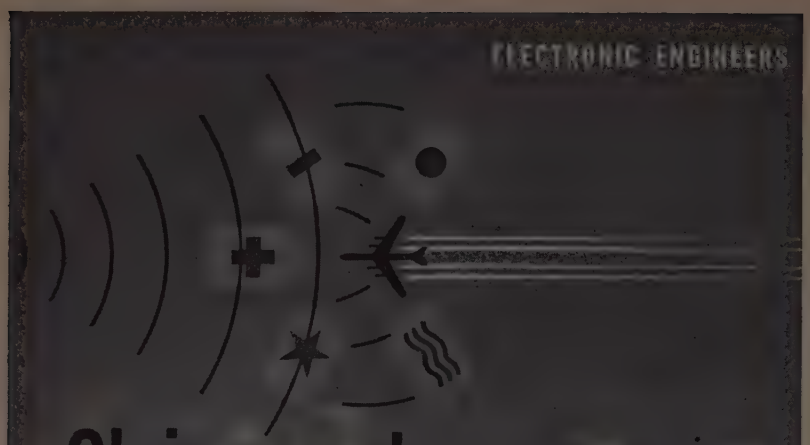

Clairvoyant Countermeasures*

—ONE OF THE MANY EXCITING PROJECTS ATTRACTING ENGINEERS TO GENERAL ELECTRIC'S LIGHT MILITARY ELECTRONICS DEPARTMENT

Engineers at LMED are developing an "Intelligent" ECM System which will instantly analyze radiations from enemy systems, make decisions and immediately respond with counter-radiations to provide continuous protection for our aircraft.

LIGHT MILITARY DESIGNS ACROSS THE ENTIRE EM SPECTRUM—FROM AUDIO TO INFRARED

The "Clairvoyant" Countermeasures system is typical of LMED's many programs that extend across the entire EM Spectrum. Other diversified programs now under way that offer accelerated career growth and substantial job security include Polaris Fire Control Computers, automated AEW, and a revolutionary Bomb/Nav system.

FOR PROMPT CONSIDERATION send a post card containing the following information: your name, home address, home phone, degree(s) and year(s) received plus the technical areas you are particularly interested in to:

Mr. R. C. Kimm, Div. 60-MC

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

* Attempting to prove the existence of clairvoyance and telepathy, early experimenters used unique "playing cards" developed by Dr. Karl Zener. LMED's ECM will appear clairvoyant to enemy radars by seeming to know beforehand, the precise signal structure to jam.

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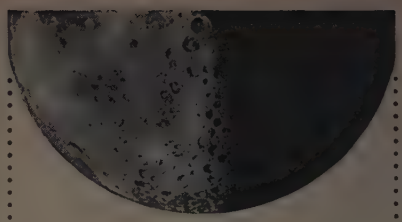

Help us solve the problems of

ION PROPULSION

Our Advanced Design Group is seeking engineers and scientists to work on low-thrust propulsion systems that will make possible the manned exploration of Outer Space. These are a few of the challenging positions:

Theoretical Physicist

Experienced in the field of particle physics, magneto-hydrodynamics and plasma physics, comparative performance of electrical propulsion systems, new methods of developing thrust from electrical propulsion systems, and direct conversion processes.

Chemical Physicists

To make studies on propellants for ion propulsion. Experienced in electronics, atomic physics, and physical chemistry.

Physicists

Primary activities will be in the field of ion sources and high vacuum techniques. Experienced in particle accelerators, ion sources, and electronics.

Electrical Engineer

Analysis of electrical power generators, preliminary stages designs of permanent magnet, AC induction and electrostatic generators.

Please write: Mr. F.C. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, Calif.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.
FIRST WITH POWER FOR OUTER SPACE

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements on which complete information was not available at the closing date (February 5) are not necessarily covered by these indexes.

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader-Service Card.

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Exceptional life under the extreme temperatures encountered in today's bonding techniques is a major cost-cutting advantage with Hewitt-Robins *silicone* bonding blankets. These rugged blankets have lasted months in service that ruined ordinary blankets in only a few days. This has been the experience at the Fort Worth plant of Convair Division of General Dynamics Corporation, where supersonic B-58 bombers are manufactured.

Produced for operating temperatures up to 500°F., these H-R bonding blankets contain many thousands of precision molded pads which permit air to be withdrawn rapidly without voids or bubbles, even when the blankets follow intricate contours. High elongation, good recovery, high tensile strength and tear resistance, and excellent heat aging properties add extra value to these top-quality silicone blankets. They are available up to 6 ft. wide, 30 ft. long, in standard gauges of 1/8 to 5/16 in., and heavier gauges on special order.

Specialists in our Aircraft Products Department can help you put today's new silicone rubber compounds to best use in aircraft, missiles, and rockets. Consult your classified telephone directory for the nearest H-R representative, or contact Hewitt-Robins, Stamford, Connecticut.

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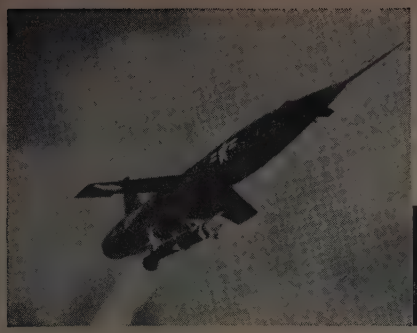


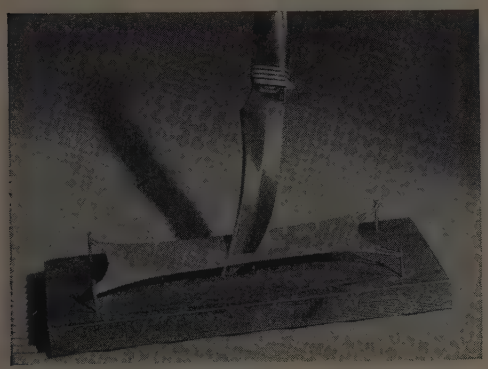
HOW TO SOLVE AIRCRAFT AND MISSILE DESIGN PROBLEMS WITH GE SILICONE IDEAS

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal, glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV silicone rubber will do all this and more. Cures at room temperature in any time you select up to 48 hours. Stable up to 600°F. Excellent electrical properties. Tough, elastic, bonds well to primed surfaces. Has good resistance to aircraft fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.

RTV sealing in Douglas DC-8 Jetliner.



New silicone rubber shows 800% elongation, 225 lb/in tear strength, 1750 psi tensile strength.

New high strength silicone rubbers meet new, tougher specifications

Last year G.E. doubled the strength of silicone rubber to make possible silicone parts with physical properties comparable to those of organic rubber. Since that time other improved and high strength G-E compounds have filled out the line. Now the requirements of almost any rubber application can be met without having to compromise between the temperature resistance of silicones and the physical strength of organics.

A number of new government and industry specifications have been written to take advantage of these developments. These specs, of course, are the best way for you to call for the properties you need and still give your rubber fabricator flexibility to use the newest available compounds. Write for a list of the latest specifications and data on new higher strength silicone rubber.

Better performance at 1/3 the cost . . . with new silicone rubber insulated wire

New thin wall constructions of silicone rubber insulated wire are replacing more expensive high temperature wire in many applications. Silicone rubber can withstand current overloads of 300 to 400%. The same test causes a higher priced insulation to decompose and fail.

Under emergency conditions silicone rubber gives maximum protection because it does not melt at high temperatures or give off toxic fumes—(when burned in a direct flame it forms a non-conducting ash which continues to insulate). It has outstanding resistance to temperature extremes, ozone, corona, radiation and cold flow. Excellent electrical properties are retained at elevated temperatures. Installation is easier because silicone rubber is truly flexible and strips easily. Write for complete technical data.

Silicone rubber insulated wire conducts even in an 1800°F flame.

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Section D813, Silicone Products Dept.
General Electric Company, Waterford, New York

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Silicone Products Department, Waterford, New York

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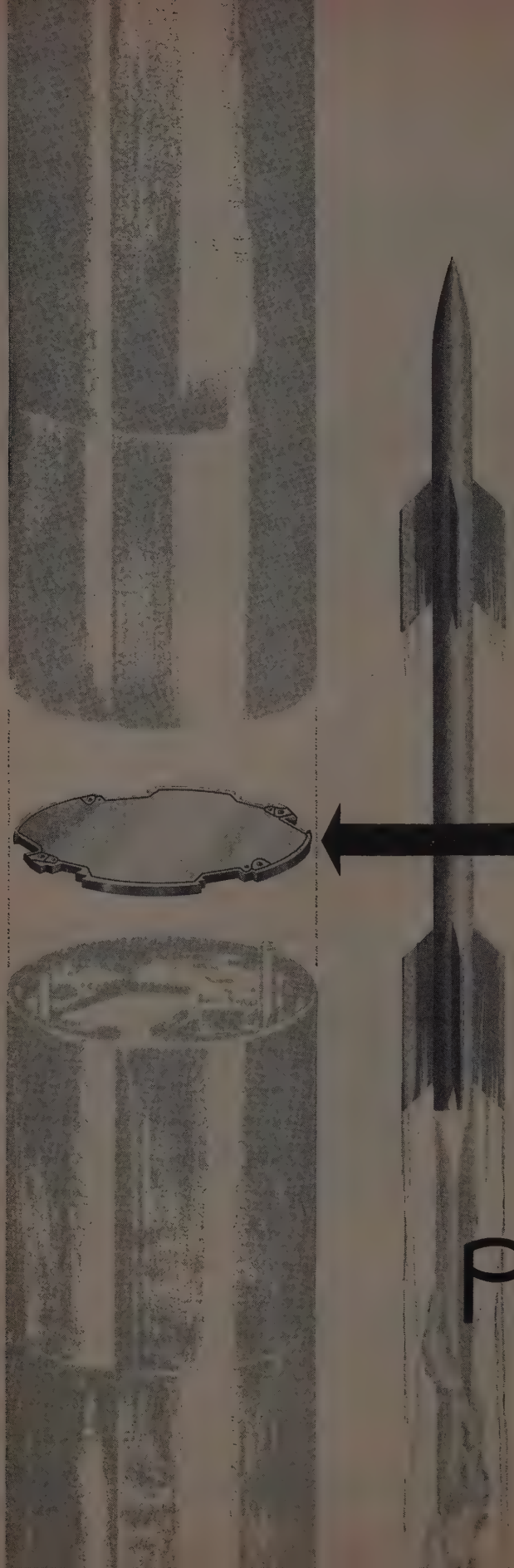

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THIS Gask-O-Seal

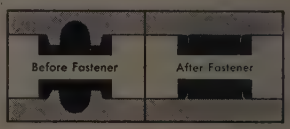
EXCEEDS HERMETIC SPECS!

Gask-O-Seals often equal or exceed *specification for hermetic* sealing. The one shown here, for instance, has eight sealing points and is on one of our newest missiles. The leakage rate is less than the original *hermetic* seal specification called for which is about as perfect as any seal can be.

Gask-O-Seals are high and low pressure static seals which require NO groove machining to accommodate. A flat surface with only a 125 RMS surface finish is all you have to provide to get positive sealing with a Gask-O-Seal.

There are many other outstanding features about Gask-O-Seals: Limited area for fluid attack, no loss of structural strength, rigid, easy to install and replace, no tolerance build-up possible in seal cavity, etc.

Why not find out about Gask-O-Seals and the other seals of Parker Seal Company's "O-Seal Family"—by the makers of Parker O-rings.



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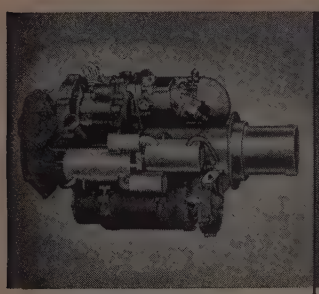
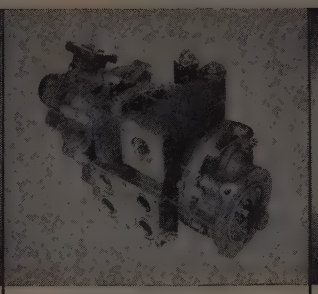
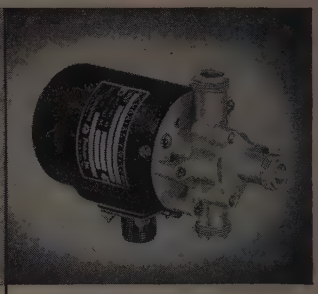


Solid-propellant auxiliary power unit

Titanium missile pressure vessel



Combination main and after-burner fuel pump



Coaxial switch

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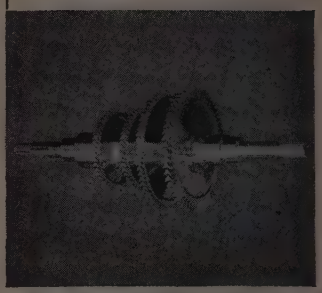
These are some of the products of the TAPCO Group of Thompson Ramo Wooldridge Inc. With $150,000,000 of high-efficiency production facilities, TAPCO is one of the nation's leaders in the development and manufacture of mechanical systems, equipment, and components that must meet stringent performance specifications under extreme conditions of temperature, corrosion, and stress.

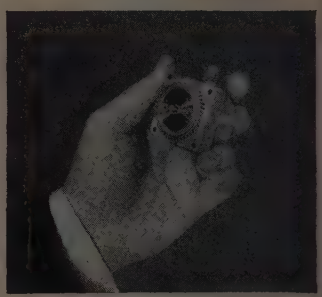
Through its metallurgical and chemical laboratories, TAPCO continually extends its capabilities in the technology of high-temperature alloys, powder metallurgy, cermets, ceramics, and other materials. TAPCO was one of the principal pioneers in the fabrication of titanium, and is currently engaged, in cooperation with E. I. du Pont de Nemours & Co., in the development of manufacturing techniques to handle niobium and its alloys.

In product design and development, TAPCO's 500-man engineering team is experienced in a wide range of specialties, including hydraulics, aerodynamics, electronics, pneumatics, thermodynamics, and nucleonics.

Aircraft and missile technology increasingly demands mechanical systems, equipment, and components that can meet uncommon requirements of precision, strength, and reliability under the most severe environmental conditions. The combination of engineering, metallurgical and manufacturing competence represented in the $160,000,000 per year activities of the TAPCO Group provides an integrated capability of unusual effectiveness for the design and manufacture of such products.

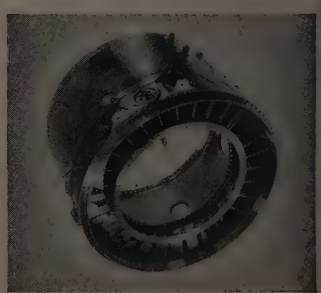


Four-stage turbine wheel



100,000 rpm turbine-driven alternator

Missile gyro ground test unit



Jet engine case assembly

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simplify materials control... standardize manufacturing processes

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THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

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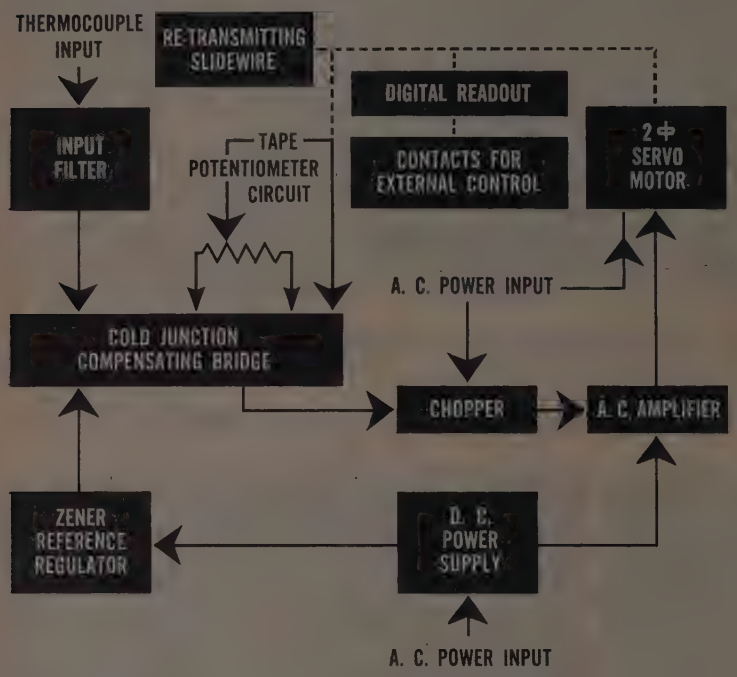


MV METER ACCURATE TO 0.1 PER CENT

ANALOG - to - digital millivolt meter developed by B&H Instrument Co., Inc., 3479 W. Vickery Blvd., F. Worth, Texas measures 3x5x5⅜ in. and weighs less than three pounds. It is a continuous null-balance, servo-driven slidewire potentiometer with transistorized amplifier and Zener-referenced power supply.

Calibration is good to at least 0.1 per cent for either linear or non-linear functions, says B&H. Linearity is 0.05 per cent and resolution is infinite.

Provision has been made for the inclusion of binary and decimal contact-making counters to provide a signal source for punched tape, magnetic tape, computers, and for controlling and programing. Switch contacts are rated at 100 ma, 115 V. Write in No. 52 on Reader-Service Card for more data.

HIGH TEMPERATURE FLEX HOSE

SPRINGFIELD 400 hose, developed by Titeflex, Inc., Springfield, Mass., has a temperature range of —65 to +400 deg F. Present diameter limit is two inches. However, the company reports larger sizes up to eight inches in diameter are being developed.

The innercore, made of Teflon tape reinforced with a fiberglass tape, is helically wound, convoluted and cured. With a stainless steel wire braid outer covering, the complete hose has a minimum bend radius of 3⅓ times the equivalent tube size. Write in No. 53 on Reader-Service Card for more information.

TRANSISTORIZED GAGE

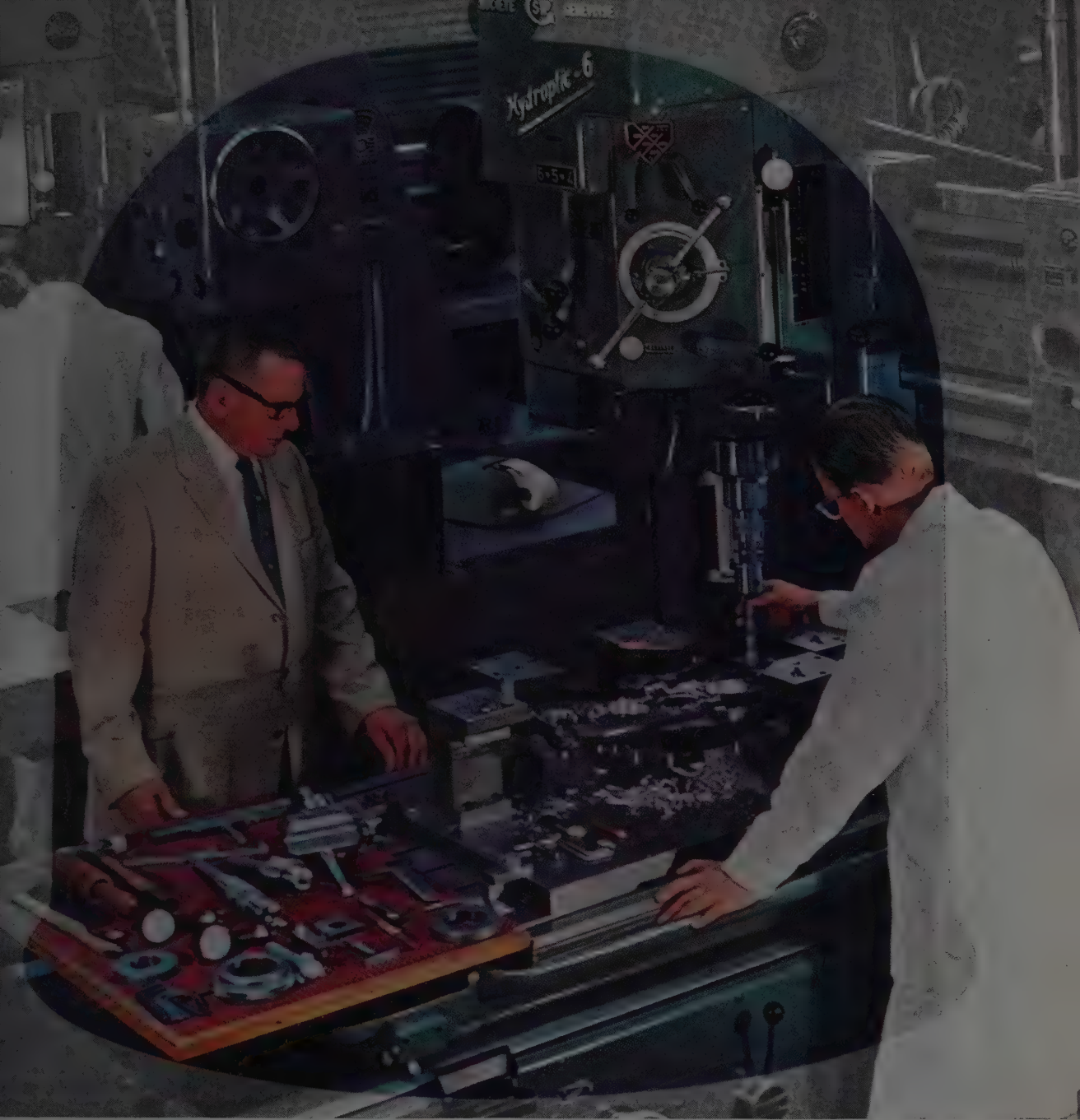
A FRICTIONLESS indicator gage head, a transistorized amplifier, and several mounting adapters make up new Microtrol 170 transistorized indicator from Cutler-Hammer, Inc., Airborne Instruments Laboratory Div., Mineola, N. Y. Simple to operate and set up, the unit can be used for surface plate or height gage work and for checking setups, runout, or alignment of parts and machines. Mounted in a shockproof, watertight case, it measure 5¾ x 5¾ x 3 1/16 in. It weighs about three pounds.

The gage head is mounted on the gaging stand or fixture. After it has been zeroed to a master part, or gage blocks, any change in the gage tip's position is greatly amplified and appears as a dimensional change on a large meter whose 4.6-in. scale is read to 10^{-7} in.

The gage head remains unaffected by the shop environment and has no mechanical amplification. The contact tip—the only moving part in the head—is supported on a single pivot spring that eliminates friction effects.

The amplifier provides two sensitivity ranges (magnifications of 7700X and 770X). The meter has a single zero-adjust control for both ranges. Write in No. 68 on Reader-Service Card for more information.

Write in No. 377 on Reader Service Card➔



Like in a huge bell jar, temperature and humidity are controlled to exacting standards in I. G. W.'s precision jig bore room.

Precision is our only product!

t Indiana Gear, precision goes far beyond the usual cus-
omer requirements. Precision is a part of order coordinating,
ngineering, production, inspection . . . a part of *every* Indiana
ear operation. Precision is a way of thinking at Indiana
ear . . . a method of always working beyond the fringe of
e state of the art.

IGW

INDIANA GEAR WORKS, INC.
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anapolis, Ind., ME 8-2331, TWX IP-174-U · Redondo Beach, Cal., FR 5-7597, TWX 7856-U · Westport, Conn., CA 7-0262, TWX 486-U

A Down-To-Earth Look At Today's Missile Picture

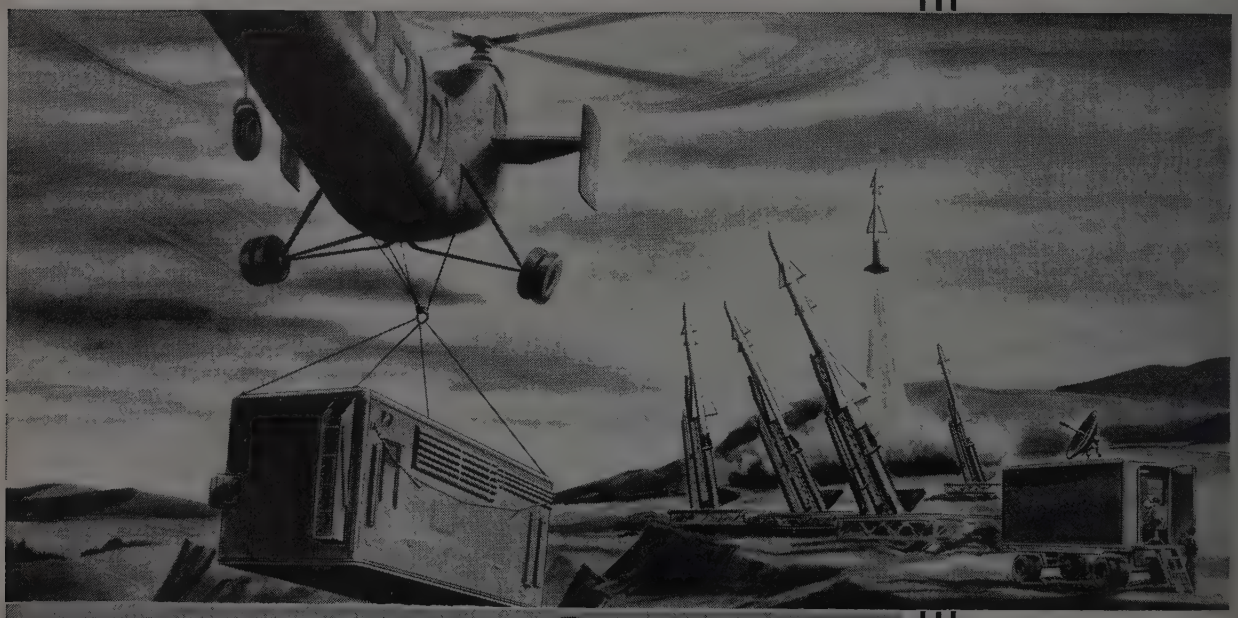
NOW that operational missiles are becoming a reality and production in quantity a fact, it has been necessary to look at the tremendous storage, transportation, and ground handling problems from a practical, dollar-conscious, down-to-earth point of view.

Each day more assignments for the development and manufacture of *practical, economical* handling units are being brought to Fruehauf, long known for its expert experience and education in commercial transportation areas. And Fruehauf has successfully responded in filling the need for the design and manufacture—at lowest possible cost—of dependable, versatile, multi-purpose ground handling units in quantity —on practically a commercial level. This is the business like approach to the missiles picture, but it must be made, and no one is better equipped and staffed than Fruehauf to do so.

Not only in relation to missiles but for *many* military ground-handling needs, Fruehauf research, engineering, and manufacturing knowledge is being utilized profitably by the services and other contractors. Here are a few of the widely varied projects with which Fruehauf has been associated in a development or manufacturing capacity:

- **Ground handling equipment for 17 missile types**
- **Missile launchers**
- **Guidance shelters for missiles**
- **Shelters for electronic and radar equipment**
- **Specialized tank-trailers for fuels**
- **Power haul vans**
- **Vans for testing equipment**
- **Standardized refrigerator vans and other mobile materials containers**
- **Formal detail specification drawings in quantity**
- **Rough terrain trailers**
- **A total of over 400 different types of military vehicles**

You can put confidence in Fruehauf's long experience and extensive facilities in meeting any ground handling problem concerning missiles, guidance shelters, weapons systems, or materials supply.



MILITARY EQUIPMENT DIVISION

FRUEHAUF TRAILER COMPANY

10942 Harper Avenue Detroit 32 5137 South Boyle Avenue Los Angeles 58

Write today for free copies of "Fruehauf Is First" . . . a series of booklets illustrating Fruehauf's missile handling experience and engineering and research facilities.

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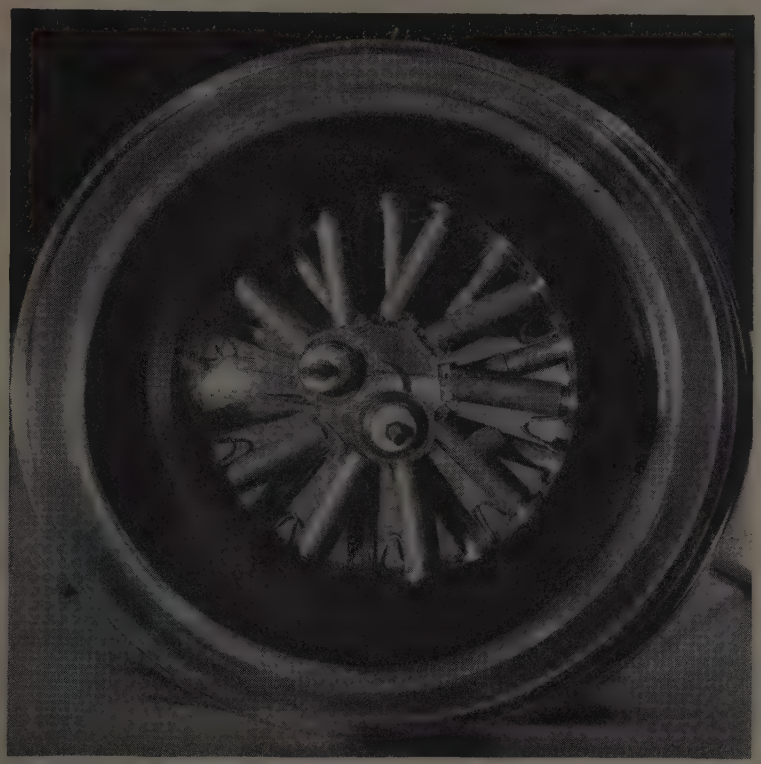
product of the month



NUCLEAR ENERGY converted into electricity

Feature Product Award

MARCH 1959

The Martin Co., Nuclear Div., Baltimore 3, Md., has developed a radioisotope-fueled thermoelectric generator that combines a radioisotopic heat source with a direct energy conversion system. Twenty pairs of semiconductor conversion elements are used. These elements, made by Minnesota Mining & Manufacturing, are lead telluride rods alternately doped to produce an excess or a deficiency of electrons.

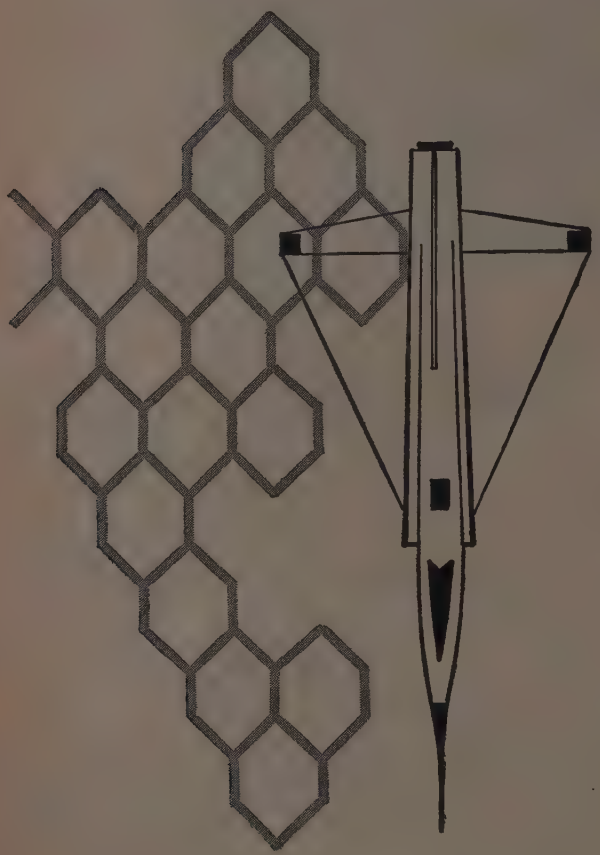
The unit has a diameter of 4.75 in., is 5½ in. high, and weighs five pounds. It can deliver 2900 W-hr/lb over about 280 days, or two half-lives of the polonium 210 isotope. Fully charged (3000 curies of Po-210), it can deliver at least two watts of continuous power over six months. It works at five per cent efficiency. The total electric output at a load of half the design charge (1500 curies Po-210) is 2.4 W.

Write in No. 33 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of aviation.

Randolph Hawthorne
Editor

HONEYCOMBS
of Armco Stainless Steels Combine
Lightness / High Strength / Resistance to Heat



Armco PH 15-7 Mo and 17-7 PH Stainless Steels provide a unique combination of advantages that enable you to design and produce maximum-performance honeycomb structures. These special aircraft steels:

- **Offer high strength-weight ratios up to 900-1000 F.**
- **Have excellent, minimum room temperature strengths.**
- **Are Available in thin sheets and foil down to .001" thick.**
- **Resist corrosion without plating or painting.**
- **Are fabricated readily by standard production methods.**
- **Yield more aircraft hardware per dollar.**
- **Have been proved by performance.**

For complete information on the properties and fabrication of Armco's Precipitation-Hardening Stainless Steels, fill out and mail the coupon.

ARMCO STEEL CORPORATION
1449 Curtis Street, Middletown, Ohio
Send me design and fabrication data on
☐ Armco PH 15-7 Mo Stainless ☐ Armco 17-7 PH Stainless

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COMPANY_____
STREET_____
CITY_____ ZONE____ STATE_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

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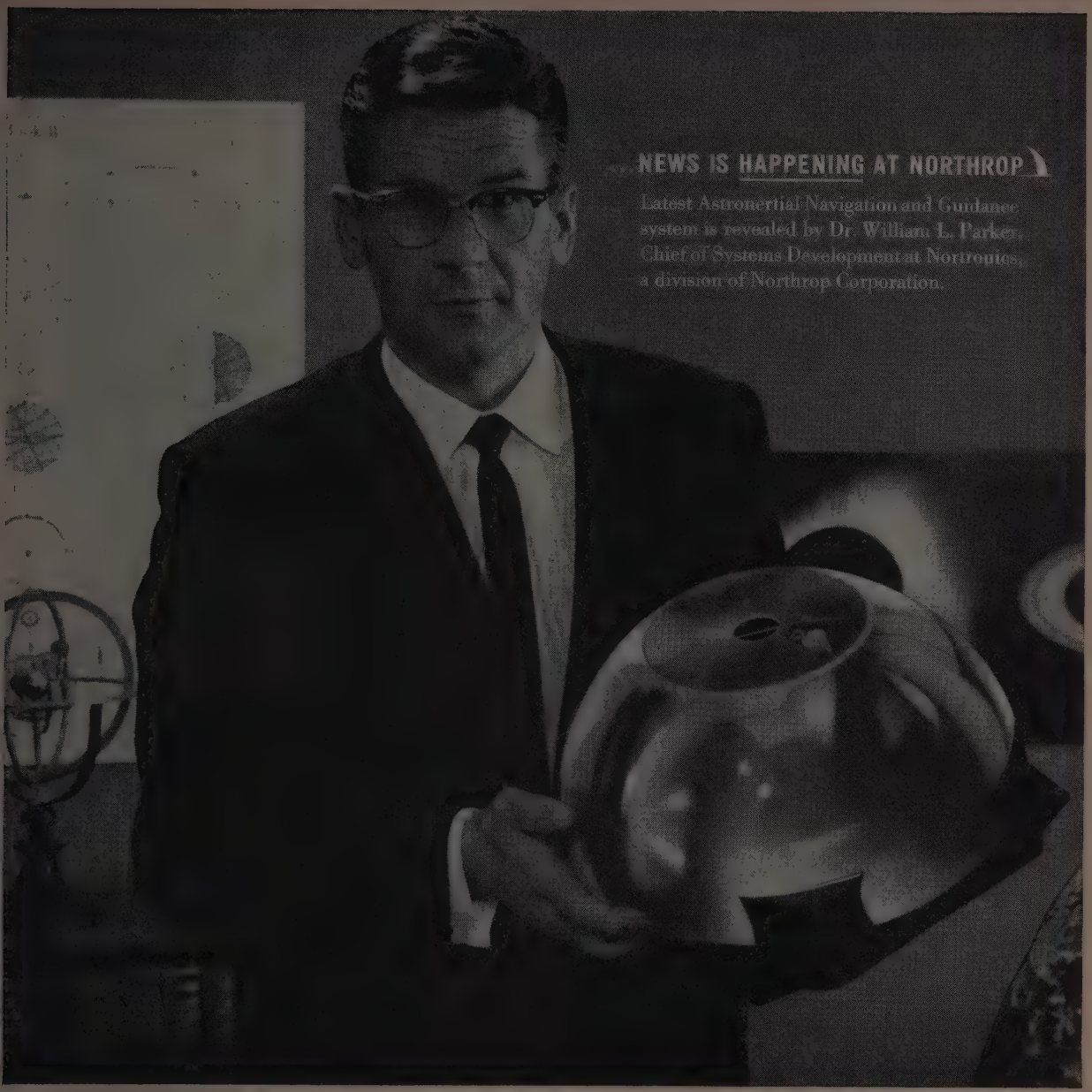

...NEWS IS HAPPENING AT NORTHROP
Latest Astronertial Navigation and Guidance system is revealed by Dr. William L. Parker, Chief of Systems Development at Nortronics, a division of Northrop Corporation.

NORTRONICS ASTRONERTIAL SYSTEM—ONLY GUIDANCE CONCEPT READY TO MEET THE CHALLENGE OF INTERPLANETARY NAVIGATION!

READY NOW for the day man first explores the planets, Nortronics' concept of Astronertial Guidance is the most accurate known for long-duration flights. Astronertial Systems now in production deliver a wide margin of added accuracy—using Nortronics' exclusive 24-hour star tracker to correct continuously for the small, then ever-compounding errors inherent in "pure" inertial systems.

OPERATIONAL TODAY in the USAF-Northrop Snark SM-62—free world's first and only operational intercontinental guided missile—Nortronics Astronertial systems have furnished accurate guidance for more miles than all similar systems combined.

CURRENT NORTRONICS SYSTEMS trim weight to one-tenth, size to one-twentieth that of original systems. They are designed to deliver pinpoint accuracy in applications to all types of space vehicles, cruise and ballistic missiles, terrestrial manned aircraft, surface ships and submarines.

NORTRONICS EXPERIENCE in Astronertial Guidance dates back to 1946—to the design and development of the first successful intercontinental system. Now, Nortronics offers unique and proven capability in design, development and production of complete and integrated guidance systems, including their ground support and test equipment.

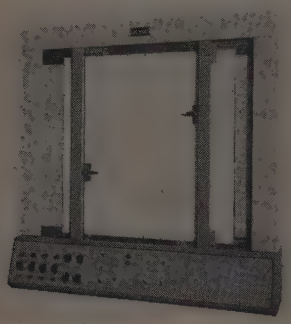
NORTRONICS

Hawthorne, California

A Division of Northrop Corporation

product preview

PLOTTER
for analog computers



The Models 205S & T automatic X-Y plotters provide greater speed, large 30x30-in. plotting surface, and higher reliability in a smaller package, says **Electronic Assoc. Inc., Dept. S/A, Long Branch, N.J.** The "Transistorized Variplotter" uses servo motors at 400 cps at greatly increased dynamic speed, coupled with reduced size and weight (250 lb). It will operate in any position from horizontal to vertical and has disposable ink cartridges, vacuum hold-down, and highly stable internal reference voltages.

Parallax controls permit locating the 0-0 position may place, on the plotting surface. Off-board parallax is available as an optional feature. Sensitivity controls are provided to attenuate input signals, thereby providing non-standard scale factors.

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ROTARY ACTUATOR
has adjustable load range

The Model D-1900 rotary actuator for aircraft, missile and ordnance equipment features a small space envelope and an adjustable electrical load sensing device that holds a predetermined load over a range of six to 17 in.-lbs, says **Hoover Electric Co., Dept. S/A, Hangar 2, Port Columbus Airport, Columbus 19, O.** The load sensor automatically stops the unit in one direction.

Normal load is eight in.-lbs at 1000 rpm, and use of the next larger size motor permits loads up to 30 in.-lbs at 200 rpm. The D-1900 includes an adjustable travel limit mechanism that permits up to 250 turns of the output shafts. Other features include a radio noise filter, integral thermal protector, and an electro-mechanical clutch-brake for low over-travel and irreversibility. The dual counter-rotating output shafts provide interchangeability of left and right hand units.

Write in No. 135 on Reader Service Card

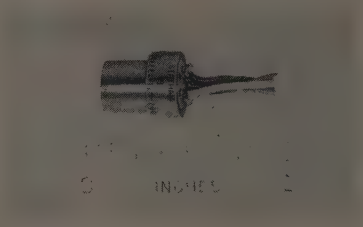
ABSORBER MATERIAL
for microwave use

Supplied in three different bulk resistivities and in the form of wet sand, Eccosorb PM is a "do-it-yourself" material that is packed in place and cured with heat to a rigid absorber body. Selection of correct properties can produce an absorber that functions at almost any chosen frequency, says **Emerson & Cuming, Inc., Dept. S/A, 869 Washington St., Canton, Mass.**

Curing into the finished absorber body is done in a few minutes at 300° F.

Write in No. 136 on Reader Service Card

TRANSDUCER
measures pressure



This remarkably small transducer of the unbonded straingage type will measure pressures from 0-10 to 0-200 psig, over a temperature range of —65° + to +250° F, says **Statham Instruments Inc., Dept. S/A, 12401 W. Olympic Blvd., Los Angeles 64, Calif.** The tiny, flush diaphragm Model P 222 has a natural frequency of about 7000 to 20,000 cps and infinite resolution.

Having an output of 15 millivolts full scale and a nominal bridge resistance of 200 ohms, the unit is intended for measurement of gage, differential, or absolute pressures. Extremely small (0.25"d x 0.31"l) the P 222 has pressure adapters for conversion to closed line use.

Write in No. 137 on Reader Service Card

POTENTIOMETER
has dual elements

Model 209 Twin Pot lead screw actuated potentiometer is a dual arrangement of two potentiometers in one compact unit that provides simultaneous control of two circuits by a single adjustment of the slotted shaft, says **Bourns Laboratories, Inc., Dept. S/A, P.O. Box 2112, Riverside, Calif.**

This model provides virtually 100% usable range and better stability and higher reliability. It measures 5/16 x ½ x 1¼ in., mounts individually or in stock assemblies using 2-56 screws through body eyelets.

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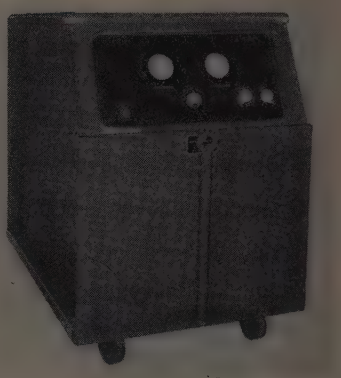
HYDRAULIC POWER
supplies in two models



Two models of hydraulic power supplies, 3000-10 and 3000-20, supply test fluid MIL-0-5606 @ pressures to 3000 psi and flows to ten and 20 gpm respectively with less than 0.30 milligrams of solid contaminant per 100 cc of fluid, says **Coleman Engineering Co., Dept. S/A, 6040 W. Jefferson Blvd., Los Angeles 16, Calif.**

To insure cleanliness of the fluid the unit features stainless steel lines, fittings, and hydraulic reservoir. A magnetic filter as well as micronic filters in the line make the exceptionally low contamination level possible. An electric motor driven variable-volume pressure compensated pump is used in the portable, caster-mounted units.

Write in No. 139 on Reader Service Card

SERVO AMPLIFIER
is transistor-magnetic

This compact servo amplifier features silicon transistors in its servo amplifier section together with an integral fast response magnetic amplifier and is ideally suited for high speed, high shock, and vibration aircraft and missile applications, says **Kearfott Co. Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.** This plug-in device, weighing only 8 oz., operates at temperatures ranging from —55 to +100 C and has a power output of 3.5 watts with either zero or 30 deg phase shift, depending on tuning capacitor selected.

Power input is 115 V, 400 cps, 210 ma, and 27 VDC, 30 ma. Input impedance is 10 K ohms and frequency response is from 0 to 70 CPS for a 400 cycle carrier. Null drift is negligible, nominal gain is 2500 or 2000, depending on unit being driven, quadrature rejection is a minimum of 20 db, harmonic rejection 12 db maximum.

Write in No. 140 on Reader Service Card

more on page 203

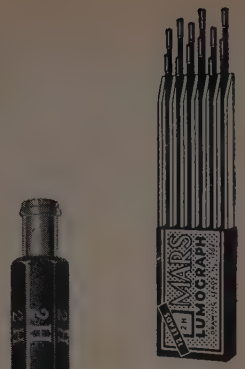
No. 14 • Mars Outstanding Design Series

SQUARE WHEELS? Yes ... square wheels. Operating by means of a floating axle and cam gear, they take the bumps out of rough terrain and provide more traction. U.S. Patent No. 2786540 has been granted to designer Albert Sfredda of Bethlehem, Pa., for his invention.

The square shape gives superior traction in mud, sand, snow or uneven terrain. The flat surfaces of the wheels bridge the ruts instead of sinking into them as do round wheels. The wheels can be in any relative position, do not need to be synchronized—yet they run smoothly. Designed for use on heavy trucks, jeeps, farm or construction machinery, speeds up to 35 miles per hour can be attained.

This ingenious departure from age-old precedent is just one example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality they require the best of drafting tools.

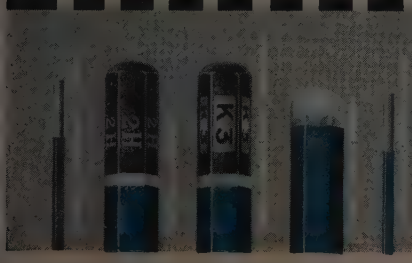
In pencils that means MARS, long the standard of professionals.



Among the famous imported Mars drafting products are: **Left** — 1001 Mars-Technico push-button lead holder. **Above** — 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** — 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film — 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** — Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

®T.M. FOR duPONT'S POLYESTER FILM



for the man who's going places...

the pencil that's as good as it looks

MARS

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

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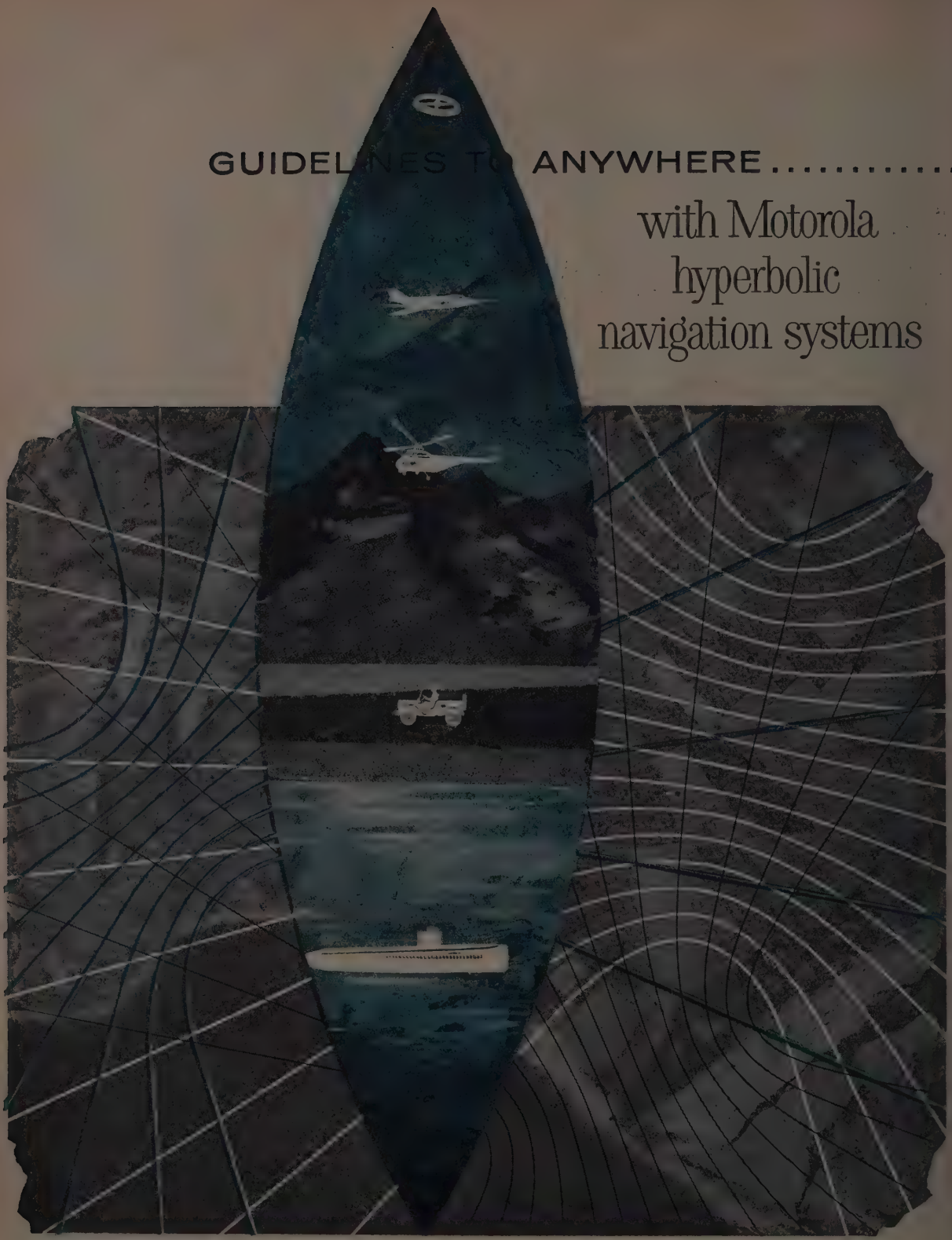
GUIDELINES TO ANYWHERE.....

with Motorola
hyperbolic
navigation systems



MOTOROLA

Military Electronics Division / CHICAGO • PHOENIX • RIVERSIDE

A-92-3

From pin-point positioning of small tactical vehicles in combat areas to critical, repetitive fixes for long-range aircraft, spacecraft, ships and submarines...Motorola leads the way, fulfilling the requirements of the military... with *guidelines to anywhere.*

Based on low frequency, CW phase comparison techniques, these short, intermediate and long-range navigation systems provide precise position coordinates without line-of-sight restrictions and with a minimum of contamination from most topographic and man-made obstacles.

Three typical military programs under contract to Motorola in the field of hyperbolic navigation are:

PINS—A short-range position fixing system for all types of tactical vehicles and combat personnel. Light in weight, accurate to within feet*, this system has been reliability-proved under a wide range of environmental conditions.

DRONE GUIDANCE—An intermediate-range system capable of accurately guiding drone aircraft. Positioning data is provided to within yards* under all conditions of weather or terrain.

RADUX-OMEGA—A long-range, very low frequency system designed to yield fractions-of-a-mile* accuracies on a global scale. Ultimately, Radux-Omega could offer world-wide positioning service for aircraft, surface vessels and submarines.

Motorola engineers have also developed specialized computers, compatible with the above systems, providing instant readout in latitude, longitude, or military grid. In these units weighing less than 7 pounds, hyperbolic data is translated with a conversion accuracy of .01%.

For unclassified* information on Motorola's extensive design advances in the field of hyperbolic phase comparison navigation systems...or for details on career opportunities...write: Motorola, Inc., Military Electronics Division, Dept. B., 8201 E. McDowell Road, Phoenix, Arizona.

**Specific capabilities of these systems can be obtained by properly cleared personnel who establish a "need to know".*

MOTOROLA

Military Electronics Division

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POWER SUPPLY *is encapsulated*

An encapsulated power supply available in a wide range of voltage current, wattage, and frequency combination is built according to government specifications, says **Telectro Industries Corp., Dept. S/A, 35-16 37th St., Long Island City 1, N.Y.**

The power supply meets Mil specification for vibration and drop testing, can withstand high altitude and high voltage applications, and has a volume resistivity up to 9.2 x 10^{12} ohms/cm^3 at 125 deg C.

Write in No. 141 on Reader Service Card

MINIATURE MOTOR *for instrument use*

This size 8 motor available to instrument and system manufacturers is only 3/4 in. in diameter and 1 3/8 in. in length. Designed as a permanent magnet motor, it is one of the smallest precision type manufactured and features precision ball bearing construction with synchro type mounting, says **Luther Mfg. Co., Dept. S/A, 7312 Varna Ave., North Hollywood, Calif.**

Using a permanent magnet field the output of the motor is proportional to the polarity and magnitude of the input voltage. It has a starting voltage down to 1½ V. The efficiency of the motor is maintained at either 12 or 24 Vdc operation and over a wide ambient temperature range.

Write in No. 142 on Reader Service Card

VOLTMETER *eliminates step switches*

Model 26-044, a self-contained unit with its own power supply and reference voltages, provides rapid digital readout of analog voltages with extreme accuracy, according to **Electronic Assoc. Inc., Dept. S/A, Long Branch, N.J.** Using printed circuit techniques, this compact instrument offers a high brilliance porjection readout to display the four digit reading, decimal point and sign.

Accuracy is 0.01% of full scale on all three ranges of 0-10, 10-100, and 100-1000 V for both positive and negative inputs.

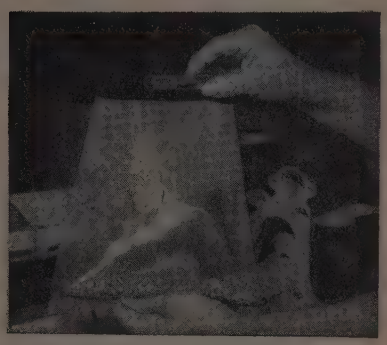
Write in No. 143 on Reader Service Card

more on page 207

LOCTITE cuts rejects from 13% to ½% on Hamilton Standard Jet Fuel Controls!

The aluminum casting of this Hamilton Standard Jet Fuel Control contains 28 pipe plugs. The assembly is subjected to hydrostatic tests with JP-4 fuel at 1500 psi. With older type sealants, only one plug in 200 leaked—but that was far from good enough for Hamilton Standard. With 28 plugs in a casting, the reject rate on the test stand was 13%. Switching to LOCTITE Liquid Sealant, they have experienced only 23 leakers in over 124,000 plugs tested . . . a reject rate of ½%.

LOCTITE is a thin liquid which hardens when confined between closely-fitted metal parts and locks against vibration. It forms a tough, heat and oil-resistant bond completely filling the joint to insure a positive seal. Hardened LOCTITE is not affected by water, military fuels, hydraulic fluids, degreasing solvents and most chemicals. It has been successfully used to seal against CO_2, oxygen, Freon, nitrogen, acetylene and LPG. LOCTITE contains no solid particles and any excess outside the joint may be wiped off . . . there is no danger of residue entering fluid stream and fouling valve seats.



At Hamilton Standard, division of United Aircraft Corp., this method virtually eliminates the labor cost of application. A day's supply of clean plugs is treated with LOCTITE by tumbling in a plastic bag. The treated parts store until used in assembly since LOCTITE hardens only when confined.

Write for literature and free sample.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY

161 Woodbine St., Hartford 6, Conn.

In Canada: J. S. Parkes & Co., Ltd., Montreal

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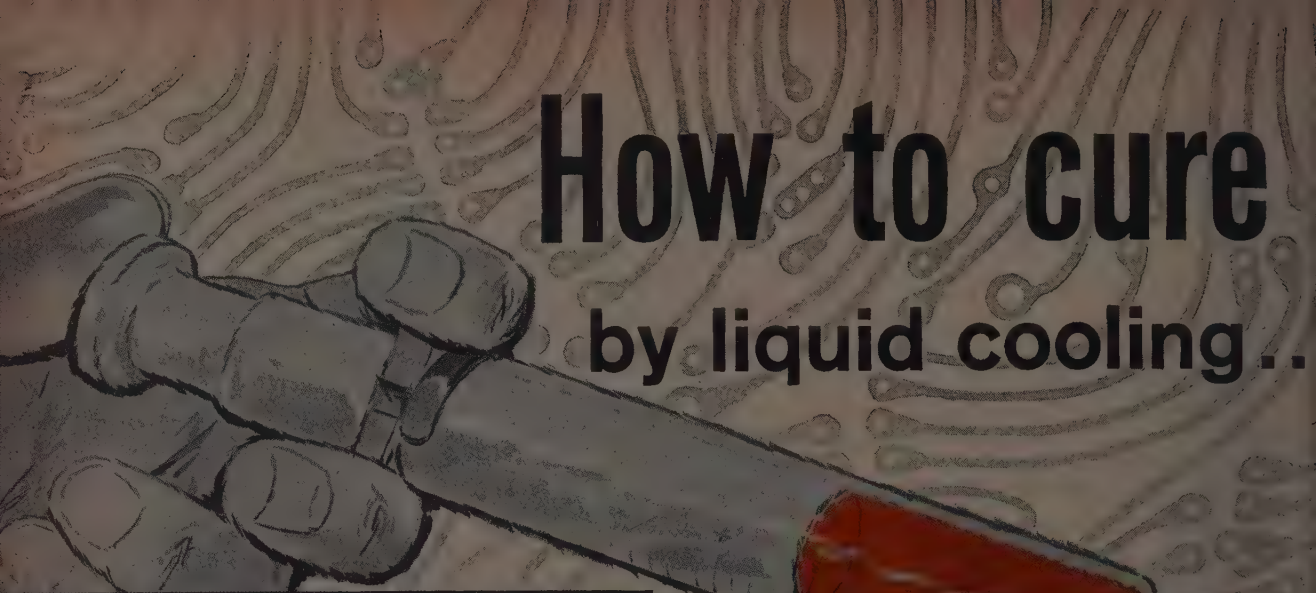
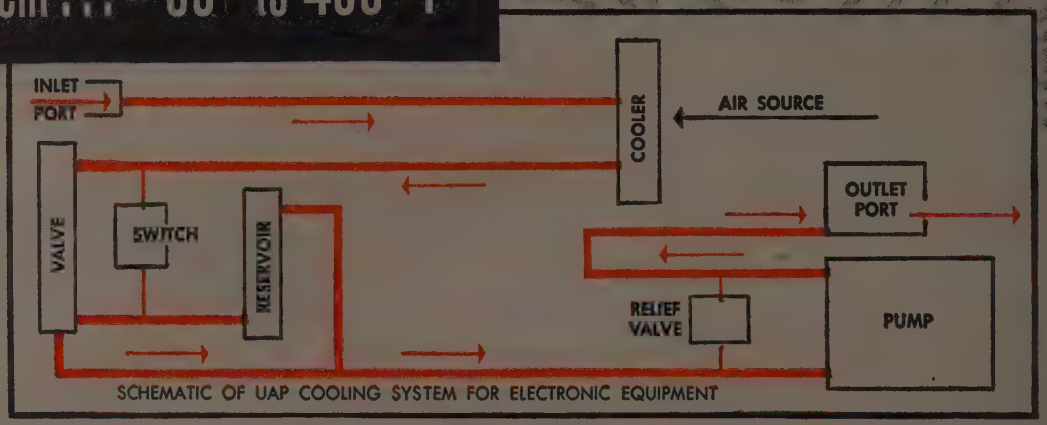
Write in No. 38 on Reader Service Card→

How to cure by liquid cooling..



MONSANTO COOLANOL* 45 coolant-dielectric for electronic equipment...—65° to 400° F



SCHEMATIC OF UAP COOLING SYSTEM FOR ELECTRONIC EQUIPMENT

For reliable operation of electronic equipment, Monsanto COOLANOL 45 maintains desired temperature control within the range of—65° to 400° F. Pumped through jacketed components, it efficiently dissipates heat through liquid-phase heat transfer. COOLANOL 45 is an excellent fluid for the "package concept" of liquid cooling systems, such as UAP's, because it can also function as a hydraulic fluid. This makes possible a one-fluid, packaged coolant and hydraulic system.

COOLANOL 45 has extremely high purity, good dielectric qualities, excellent lubricity, low foam tendency, and good viscosity properties over its wide temperature range. The fluid is compatible with common materials and its non-toxicity simplifies handling methods. For complete technical data, write today for Technical Bulletin AV-3 on COOLANOL 45. Address:

MONSANTO CHEMICAL COMPANY
Aviation Fluids Department AV-6
Lindbergh and Olive Street Road
St. Louis 24, Missouri

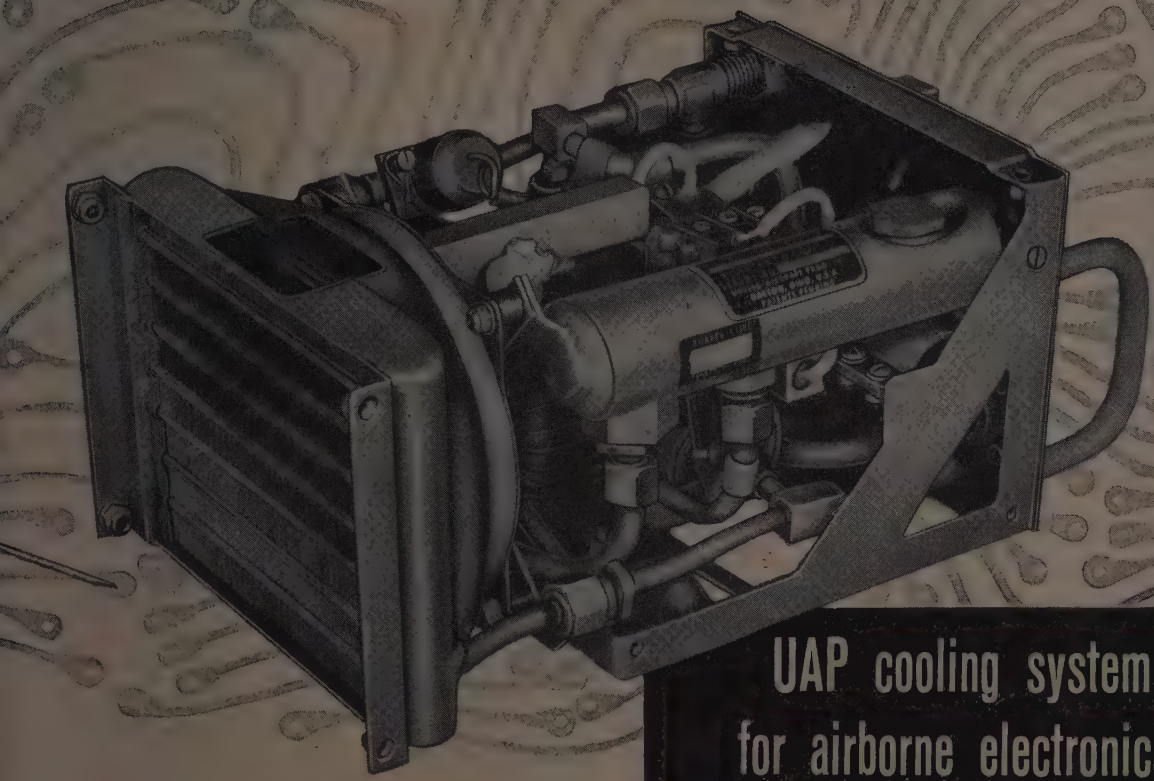
Coolanol: Monsanto Trademark.

Present systems using Coolanol 45 . . .

Fire Control	Radar (ground and air)	Guidance
Communications	Navigation	Bomb-Navigation
Data-Link	Telemetering	

Monsanto

electronic fever"



UAP cooling systems for airborne electronics

UAP Cooling Systems assure safe operating temperatures for ground or airborne electronic equipment in applications such as automatic flight, weapon fire control, communication, navigation, and mobile ground support and test equipment. Typical systems consist of heat exchanger, fan and motor, pump and motor, expansion reservoir, and safety controls to protect the system and customer's equipment. The entire package is contained in an envelope of strict space and weight requirements.

U-518078-3, shown above, is 9 x 5.9 x 4.4 inches and weighs 6.75 lbs. exclusive of coolant fluid. Heat load of 275 watts is transferred from the electronic equipment to Monsanto COOLANOL 45. The pump circulates 1¼ to 3½ gpm through the cooling system. Forced air through the heat exchanger maintains fluid outlet temperatures that vary between the extreme design points of 192° F. at sea level (air-in temperature 160° F.) and 220° F. at 70,000 ft. altitude (air-in temperature 36.5° F.).

Get complete information on UAP electronic cooling systems . . . or submit your application problem today for UAP design study! Call the nearest UAP Contractual Engineering Office: Burbank, California VI-9-5856; New York, N. Y. MU-7-1283; Dayton, Ohio BA-4-3841; Montreal, Canada ME-1-4396.

UNITED AIRCRAFT PRODUCTS, INC.
1116 Bolander Avenue, Dayton, Ohio

UAP — UNITED AIRCRAFT PRODUCTS, INC. ®

Custom designed UAP electronic equipment cooling packages incorporate mechanical, and expendable refrigerant systems; cold plates, gas-air and liquid-air heat exchangers.

big coupling for hot tailpipes

. . . high-temperature ducts and missile applications

Janitrol's new lightweight, non-torquing line of large diameter couplings provides a safe, easy to connect or disconnect, vibration-proof seal. They are simple to install, clamp together without need of a torque wrench, and assure positive alignment. Clamp latch cannot be closed unless pipe sections are correctly oriented. Total weight of the 36″ diameter clamp and two flanges is only 9.7 pounds. Clamp diameter adjusts to meet pipe production tolerances; a safety lock pin gives extra protection.

Test data: Model illustrated is tested to 15G's with tail pipe attached, and at temperatures to 900°F. Vibration requirements of MIL-E-5272A are met.

Janitrol couplings are supplied in stainless steel, with flanges of titanium, aluminum, or steel, in a wide range of sizes down to 1″ in diameter.

When you require high performance couplings for tail pipes or ductwork see your Janitrol representative.

Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 4, Ohio.

schematic cross-section of standard coupling

schematic cross-section of flush coupling

JANITROL®

pneumatic controls • duct couplings & supports • heat exchangers
combustion equipment for aircraft, missiles, ground support

Write in No. 39 on Reader Service Card at start of Product Preview Section

RATE TURNTABLE is highly accurate

The Model 063 sidereal rate test turntable for measuring drift or error of gyroscopic and inertial equipment can maintain position to plus or minus three sec of arc throughout a 360-deg rotational cycle, says **J. W. Fecker, Inc., Dept. S/A, 6592 Hamilton Ave., Pittsburgh 6, Pa.** The unit, a positively-driven, equatorially-mounted platform, **rotates at exact**, preset rates equal to the earth's rotation, or at multiples thereof.

Nullification of the rotational effect of the earth allows the equipment under test to be isolated in inertial space or evaluated under known drift rates. The drive system is housed in the table's pedestal; a separate chassis holds the power amplifier, which is impedance-matched to the motor.

Write in No. 144 on Reader Service Card

TRANSFORMER is radiation-resistant

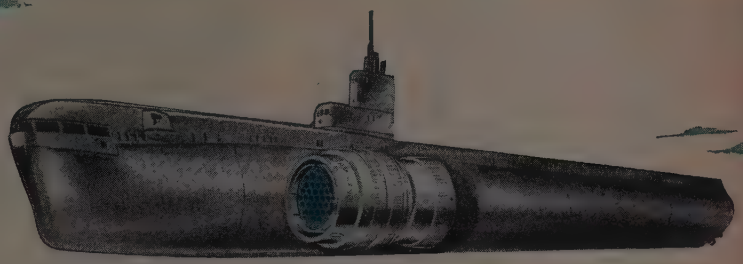
A linear, variable, differential transformer has been fabricated from inorganic materials that resist stuctural damage even when exposed to fluxes such as are found within reactor cores or in atomic explosions, according to **Schaevitz Engineering, Dept. S/A, Route 130 & Schaevitz Blvd., Pennsauken, N.J.** The radiation-resistant Series R transformers can withstand a total integrated flux of 3×10^{20} neutrons or gamma/cm^2.

The unit is available for almost any audio frequency excitation from 50 to 20,000 cps, and in a wide range of sizes. Output voltage is completely stepless and is a precise linear function of core displacement. Normal ambient temperature operating range is —65 to +450 deg F.

Write in No. 145 on Reader Service Card

more on next page

Write No. 40 Reader Service Card >



THE FLYING SUBMARINE

"Flying Submarine" describes AMPHENOL's new *MINNIE* 67 series connector; it may seem a large and unlikely name to fasten on such a small connector, but it's quite accurate. Here's why: The performance conditions under which these miniature "E" connectors will operate reliably are exactly like those encountered by a submerged submarine—flying at 80,000 feet altitude.

"Flying Submarine" also means *altitude-moisture resistant.* Under a test recently devised by industry and the armed services, wired *MINNIE's* are completely submerged in salt water, altitude cycled to 80,000 feet for one minute, 65,000 feet for one half hour and then returned to ambient pressure for another half hour. Following this test, the minimum insulation resistance of *MINNIE* connectors is 1000 megohms, well in excess of the 100 megohms required by MIL-C-5015 after moisture exposure.

What can a "Flying Submarine" do for you? If you use electrical connectors in aircraft, missile or naval applications (including non-flying submarines), *MINNIE* connectors provide *assured environmental resistance to moisture* at sea level and at high altitudes. Write for complete information on AMPHENOL'S *MINNIE* connectors!

AMPHENOL'S *Authorized Industrial Distributors stock MinniE's and other standard* AMPHENOL *components—and provide on-the-spot delivery.*

AMPHENOL *connector division*
AMPHENOL-BORG ELECTRONICS CORPORATION
chicago 50, illinois

All of the established Cherry High Clinch features are now in the "800" Monel rivets:
(1) high clinch; (2) positive hole fill; (3) wide grip range; (4) uniform stem retention; (5) positive inspection —which now includes grip length stamped on rivet head.

New design concepts are possible with the complete line of Cherry High Clinch rivets. Smaller fasteners—stronger materials—a complete range of temperature and strength applications suited to your problems. The new Cherry "800" in Monel, the "700" in aluminum, and the "600" high-strength, high-temperature rivet in A286 stainless steel give you a complete selection—all in the same proved Cherry High Clinch configuration*.

For technical data on the new Cherry "800" Monel and other Cherry High Clinch rivets, write Townsend Company, Cherry Rivet Division, P. O. Box 2157-P, Santa Ana, Calif.

*Patents issued and pending

CHERRY RIVET DIVISION
SANTA ANA, CALIFORNIA
Townsend Company
ESTABLISHED 1816 • NEW BRIGHTON, PA.

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*
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KLYSTRON AMPLIFIER needs little adjustment

A new, wide tuning range klystron amplifier tube with internal resonant cavity circuits is capable of tuning from 1700 to 2400 megacycles. The VA-800 klystron is a high-power, high-gain, low-noise CW power tube delivering 10KW and one KW of power for tropospheric communication service in the frequency range from 375 Mc to 8500 Mc. The only rf connections to the unit are an input line with less than one watt of drive power and an output line to carry 10,000 W of rf power to the antenna. All resonant circuits are an internal part of the tube and can be tuned readily to any spot in the 1700 to 2400 Mc band. No other physical adjustments are required, says **Varian Assoc., Dept. S/A, 611 Hansen Way, Palo Alto, Calif.**

The freedom from physical, electrical, and vital maintenance adjustments removes the possibilities for misadjustment, eases systems maintenance, and helps provide reliability and low cost operation.

Write in No. 146 on Reader Service Card

DELAY LINE has greater range

Greater versatility is featured by the new Deltime Model 125 delay line. Based on the magnetostrictive principle it is adjustable between 20 and 55 microseconds, with four adjustable outputs. It takes a two microsecond pulse input, with 27 db insertion loss, and delivers a 1000-ohm output to associated equipment, says **Deltime Inc., Dept. S/A, 608 Fayette St., Mamaroneck, N. Y.**

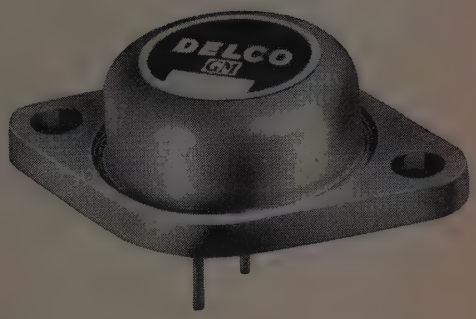
It is housed in an aluminum metal case measuring 17x3x1½ in. Front panel has the pickup coil studs sliding in a slot and locked in position by knurled thumb nuts.

Write in No. 147 on Reader Service Card

more on page 211

DELCO POWER TRANSISTORS

NEW TYPES



MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c=0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c=2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

See you at IRE Show, Booth 1512.

DELCO RADIO
Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

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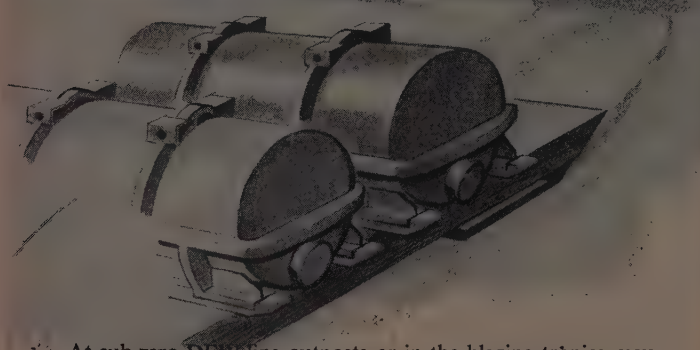
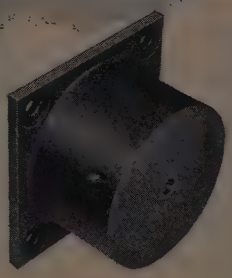
NOW! Shock protection at −65°F. with BTR Elastomeric Mountings!





BTR Elastomeric Shipping Container Mounting

Consistent performance over broad temperature range is demonstrated by results of 18″ drop tests.

At sub-zero DEW-line outposts or in the blazing tropics, you can now protect critical equipment against damage from rough handling.

Shipping container mountings made with LORD's remarkable new BTR (Broad Temperature Range) elastomer meet military packaging specifications from —65° to +165° F. In addition to positive protection, you will benefit from all the advantages of elastomeric systems—compactness, light weight, ease of installation and excellent shock absorption characteristics.

BTR Mountings are now furnishing dependable all-climate protection for high-reliability missiles, missile components and other equipment.

In these and other applications their simplicity makes them less costly, less complex than other suspensions. Inherent damping eliminates need for auxiliary dampers. Despite severe environmental conditions they resist deterioration and provide excellent performance over a long service life.

BTR Mountings are the only elastomeric mountings which meet the rigid requirements of military packaging specifications over the entire operational temperature range. For more information on the advantages of these new mountings, contact your nearest LORD Field Engineer or the Home Office, Erie, Pa.

LORD
BONDED RUBBER

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
CLEVELAND, OHIO · SHadyside 9-3175
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · Diamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

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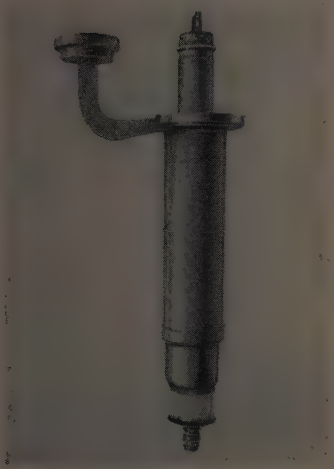
RADAR AMPLIFIER *has 28 db gain*



A one-mw, TWT amplifier for modern radar, said to be the first successful commercially available traveling wave tube, is the first in a series of wideband amplifiers planned by **Varian Associates, Dept. S/A, 611 Hansen Way, Palo Alto, Calif.** The liquid-cooled VA-125 has a 2.7 to 3.0-kmc range, and is intended to cover a large portion of the S-band without tuning.

The device is expected to contribute to greater freedom in radar design. The useful bandwidth is 375 mc, power gain is 28 db, and pulse beam voltage and current are 110 kv and 60 amps, respectively. The tube can be operated at a duty cycle of .002.

Write in No. 148 on Reader Service Card

COAX CONNECTORS *for high voltages*

These coaxial connectors have a rated corona level exceeding 15 kv ac, and a dc breakdown level of over 50,000 V, according to **H. H. Buggie, Inc., Dept. S/A, Box 817, Toledo 1, O.** They will function at a temperature of -55 deg C and under conditions of humidity, salt spray, vibration and shock.

No soldering cup is required since electrical connections are made by molded-on pigtails. Each connector has an anti-fouling, bayonet-type engagement for quick manual connect or disconnect. The brass connector receptacles have single male-type contacts, and the plugs have a taper design to remove surrounding air when plug and receptacle are mated. In this way, corona initiation is forestalled.

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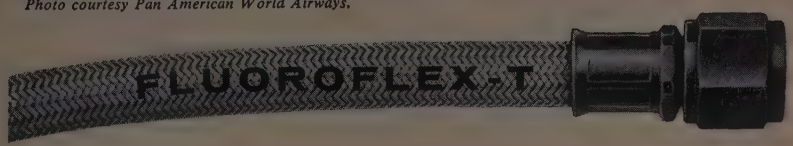
more on next page

Photo courtesy Pan American World Airways.



MODERN military jets have proven Fluoroflex®-T (Teflon®) hose in rugged service. Now the fast new commercial airliners use this same hose—for safety *and* economy.

Fluoroflex-T hose, with patented, specially compounded tube of Teflon, is non-aging—has no shelf or service life limit. Originated by Resistoflex, Fluoroflex-T was the first Teflon hose and it has been flying for five years on all types of jet and reciprocating engines and aircraft. It is available with compression-type fittings or "Seal-Lock*" reusable fittings.

Always specify the hose with highest performance and capabilities—not only for safety's sake, but for savings as well. Send for details. Write Department 221 RESISTOFLEX CORPORATION, Roseland, New Jersey. Other Plants: Burbank, Calif.; Dallas, Tex.

**T.M., Pat. No. 2,853,319*

® Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
® Teflon is DuPont's trademark for TFE fluorocarbon resins.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex

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STACKPOLE

Quick-filming

BRUSHES

THE FIRST COMPLETE LINE
FOR HIGH ALTITUDE SERVICES

Electrographitic, Carbon-Graphite, Metal-Graphite, Treated Copper-Graphite and Treated Silver-Graphite grades for maximum performance on all types of equipment *with no sea level filming run.* Send letterhead request for Bulletin 21.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

BRUSHES for all rotating electrical equipment. • ELECTRICAL CONTACTS • BEARINGS • GRAPHITE CHEMICAL ANODES • GROUNDING ANODES • POWER TUBE ANODES • SEAL & CLUTCH RINGS • VOLTAGE REGULATOR DISCS • HEATING ELEMENTS • FRICTION SEGMENTS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE RESISTORS • WELDING CARBONS . . . and many other carbon, graphite and metal powder products.

Write in No. 45 on Reader Service Card at start of Product Preview Section

OSCILLOSCOPE is portable

The Model 301 oscilloscope has a bandwidth from dc to 6 Mc (–3 db), fully automatic sync and trigger level selection, and precise time and voltage calibration, says **The Scopes Company Inc., Dept. S/A, P.O. Box 56, Monsey, N.Y.**

The oscilloscope also features "2" axis modulation, internal-external trigger selection, and an attenuation which permits accurate use of probe.

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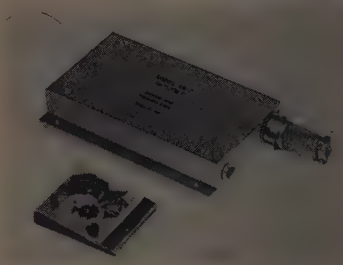
AMPLIFIER is subminiature



Model 2617, an airborne subminiature amplifier, is for use with high impedance transducers such as piezo-electric and capacitive devices. The unit has a 1000 megohm input impedance with less than 50 mv residual noise (shorted input, a range of 2 cps to 20 kc and low current requirement (5 ma), says **Endevco Corp., Dept. S/A, 161 E. California St., Pasadena, Calif.**

When used with the manufacturer's accelerometers and Model 2980 insulated mounting studs, the system is electrically isolated from ground. A selectable fixed gain of 10, 30, or 100 is preset at factory. The amplifier is potted, has military type output connectors and is 7.5 cubic in. in volume and weighs 7 oz.

Write in No. 151 on Reader Service Card

POWER SUPPLY uses semiconductors

Model PS 4004 semiconductor power supply meets all applicable military specifications, according to **Power Sources Inc., Dept. S/A, Burlington, Mass.** Nominal input voltage of 105-125 V ac 50-63 cps, selected by front panel switch, may be varied in accordance with Mil-E-4158A. Output voltages are 260-300 or 130-150 V dc. Output impedance is less than 0.1 ohms from dc to 100 kc.

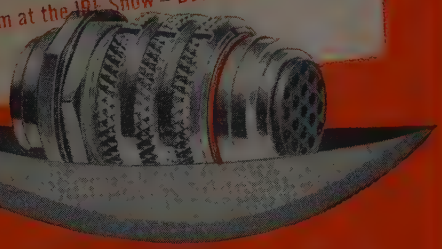
Stabilization is less than ±0.05 V on 300 V output, and less than ±0.025 V on 150 V output. Ripple and noise averages less than 1 mv and drift less than 0.02 V after ½ hr warmup.

Write in No. 152 on Reader Service Card

more on page 214

Rx Prescribed for your system!

see 'em at the IRE Show – Booth 3907



NEW! NEW! NEW!

Deutsch Miniature Connectors with completely reliable "Snap-In Contacts"

- **CRIMP-TYPE TERMINATIONS**
- **HI-TEMP SILICONE INSERTS**
- **ENVIRONMENTAL TO 30 PSI**
- **SIMPLE, FOOL-PROOF TOOLS**

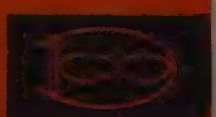
Available in a wide range of shell-sizes with either pin or socket arrangements – all of them interchangeable with existing Deutsch DM5000 and DM9000 series miniature connectors. "DS" series plugs have the exclusive Deutsch designed and developed ball-lock coupling-ring... just push-in to connect; pull-back to disconnect.

For complete information, see your Deutsch representative or write for data file 3E.

...see them demonstrated at the IRE Show–Booth 3907

The Deutsch Company

7000 Avalon Blvd., Los Angeles 3, Calif.



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PHOTODIODE is tiny

The new IN77B junction photodiode, with a diameter of 0.077 in. is applicable for highly compact assemblies where space is at a premium. It is designed for rapid, highly sensitive scanning and reading applications. It is also adaptable to infrared detection and heat-seeking devices, says Sylvania Electric Products Inc., Dept. S/A, 1740 Broadway, New York 19, N. Y.

The unit is hermetically sealed in glass with a built-in lens that focuses light on the sensitive portion of the junction. The light interruption frequency response of the photodiode is flat from 300 cycles to 15 kc at 100 per cent with 260 lumens per sq. ft. Maximum ambient temperature is 75 deg C.

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more on page 216

RIVETS and NAILS TO "AN" SPECIFICATIONS

Air Force Approved Facilities
Immediate Delivery, Many Sizes
Economically Cold Headed in
STEEL · STAINLESS (including AMS 7228C)
MONEL · INCONEL · COPPER

SPECIAL NAILS RIVETS SCREWS
Hassall
SPECIAL NAILS RIVETS SCREWS

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MANUFACTURERS SINCE 1850

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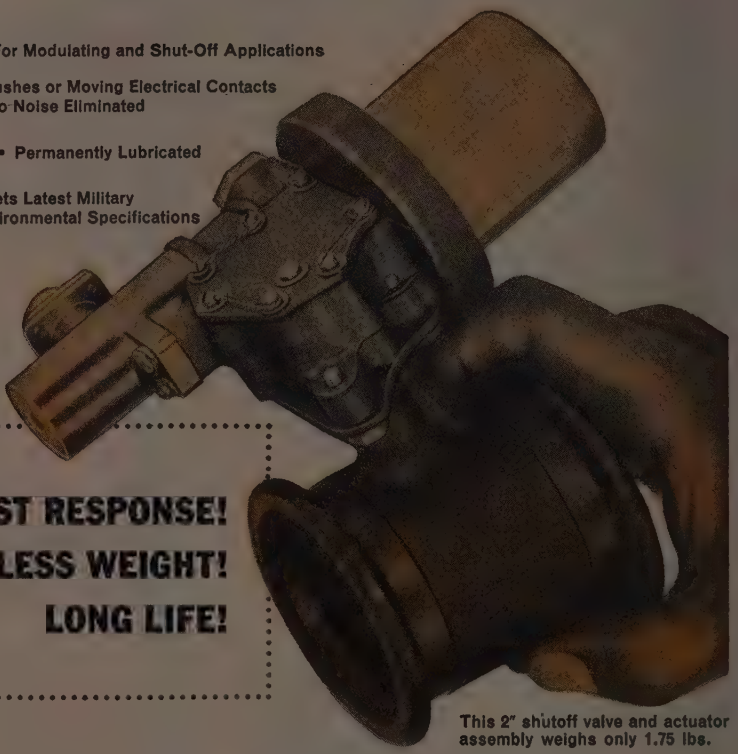
• For Modulating and Shut-Off Applications
• No Brushes or Moving Electrical Contacts —Radio Noise Eliminated
• Permanently Lubricated
• Meets Latest Military Environmental Specifications



FAST RESPONSE!
LESS WEIGHT!
LONG LIFE!

This 2" shutoff valve and actuator assembly weighs only 1.75 lbs.

NEW VĀP-AIR PRECISION
AIR TEMPERATURE CONTROL SYSTEMS AND VALVES

Electro-pneumatic operation for cabins, cockpits, pressure-suits, electronic equipment, canopy and windshield defogging, ram-air shutoff, and similar uses

Delivers any selected response from 1 to 10 seconds in ducts with 1" to 4" opening, pressure to 300 psi, and temperatures of −65°F to 1000°F. Impedance level of less than 500 ohms eliminates terminal problems. Fast, accurate operation—no relays or limit switches required.

Detailed Data for Those Who Design for Flight

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Please send new Bulletin 680 describing Vāp-Air Electro-Pneumatic Air Temperature Control Systems.

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NIKE HERCULES

With deadly accuracy the U.S. Army's new Nike Hercules ground-to-air guided missile streaks out to meet an approaching enemy air force. Its nuclear warhead can wipe out an entire formation.

Western Electric selected Teflon* insulated wire for use in building the alert guidance and control systems of this faster, higher climbing Nike.

As leading specialists in high temperature insulated wires and cables, the men and women at Hitemp are proud of this choice, and the role Teflon wiring plays in giving America a strong new perimeter of defense.

HITEMP WIRES, INC.

1200 SHAMES DRIVE, WESTBURY, NEW YORK

*Du Pont's trade name for Tetrafluoroethylene

VISIT OUR BOOTH #4215, I.R.E. SHOW, N.Y.C.

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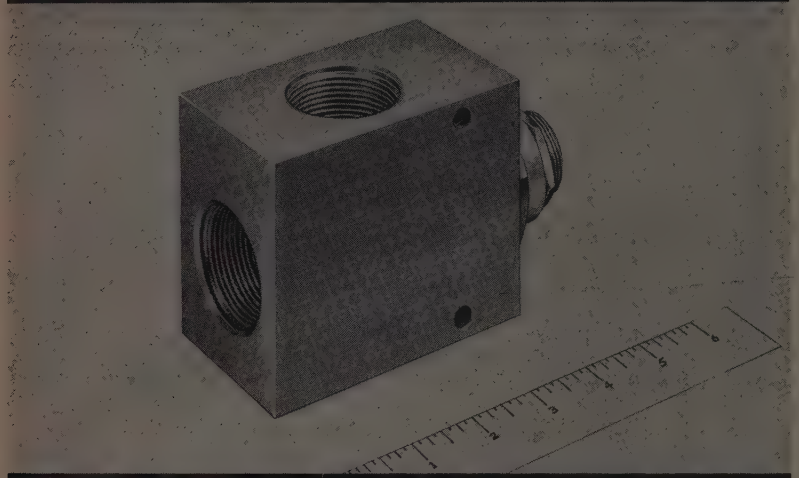
NEW . . . Large Capacity
RELIEF VALVE
For Ground Handling
And Support Equipment



- Pilot Operated — no chatter
- Flows — 5 to 130 gpm
- Low Pressure Drop
- Operating Pressure — externally adjustable
- Variations in pressure rise and hysterisis curves is negligible
- Cartridge type design permits overhaul without disconnecting lines

• Designed especially for use in hydraulic, lubricating and fuel systems, this unique unit far exceeds customers' specifications. Its exceptional performance is typical of the valves and fluid control devices designed and engineered by Fluid Regulators Corp.

SPECIFICATIONS

Capacity: 130 gpm. max.
Adj. Pressure Range: 50 to 1200 psi
Proof Pressure: 2000 psi
Burst Pressure: above 3000 psi
Low Pressure Rise: 15 psi at 55 gpm
Internal Leakage: 5 cu in/min @ Max. Pressure
External Leakage: Zero
Fluids: MIL-0-5606, MIL-F-1711, etc.
Pilot Drain—External or Internal
Construction: Al. body with S.S. and Al. cartridge valve
External Dim: 2½"x3½"x5½"
Ports: AND 10050-20
Mounting: Two Holes — 5/16"
Wt.: 4 lbs. 11 oz.
Temperature: −65° to +250°F.
Part No. 7439
Other sizes and capacities available on special order.

Write for detailed literature.

Designers and Manufacturers of Hydraulic and Fuel Valves For Missiles, Aircraft and Other Exacting Applications.

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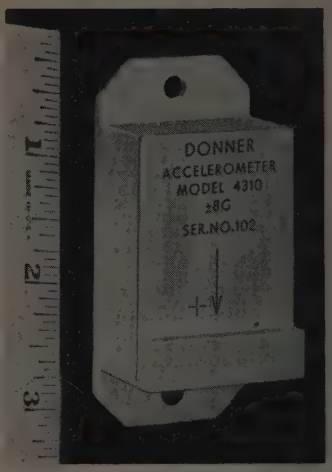
ACCELEROMETER is transistorized



The Model 4310 linear servo accelerometer is a completely transistorized unit designed in ranges from ±0.05 to ±50 g. Auxiliary amplifiers are not needed because of the ±7.5-V or ±1.5 ma output, says **Donner Scientific Co., Dept. S/A 888 Galindo St., Concord, Calif.**

Repeatability is 0.01 per cent of full scale and linearity is within 0.05 per cent of full scale. The device weighs 3.2 oz and is about three in. long.

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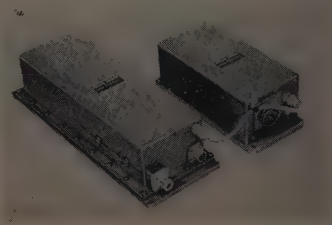
MULTICODER has solid-state design

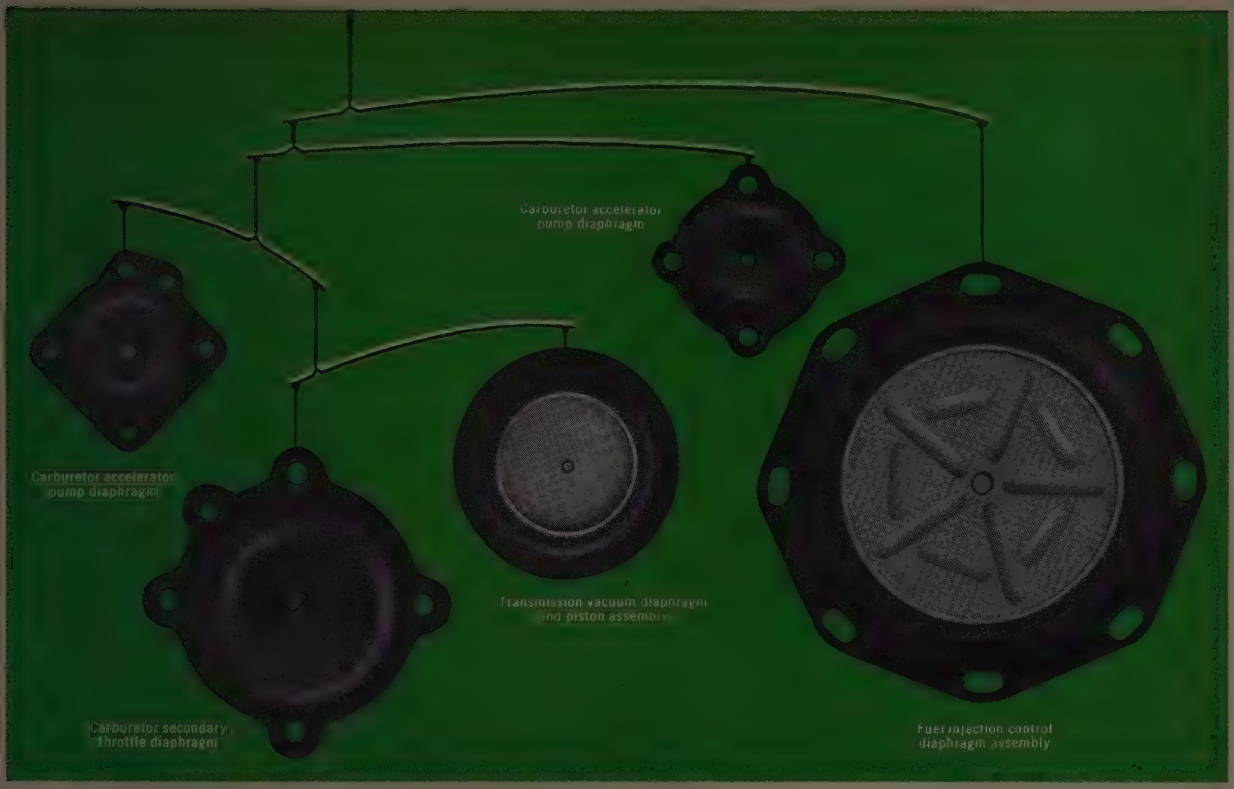


A 30x30 PDM/FM airborne telemeter, the first completely solid-state pulse duration modulation multicoder, is being used in a major missile program, according to **General Devices, Inc., Dept. S/A, Princeton, N.J.** It is also available in all standard IRIG sampling configurations for PAM and PDM applications.

Components include a solid-state electronic commutator, keyer and power supply designed for zero to plus five-V operation. Incorporated in both multicoder and its companion VHF/FM transmitter are internal power supplies for operation from +28 V dc. Linearity of the device is better than .25 per cent.

Write in No. 155 on Reader Service Card

more on page 218


Carburetor accelerator pump diaphragm
Carburetor accelerator pump diaphragm
Transmission vacuum diaphragm and piston assembly
Carburetor secondary throttle diaphragm
Fuel injection control diaphragm assembly

Need Critical Diaphragms?

C/R will design, compound and mold them to your exact specifications

Simple or complex, your diaphragm problem can be solved quickly, dependably with the help of C/R Sirvene engineers. Their specialized experience gained in the solution of hundreds of similar problems is yours to use. They will design and compound the correct elastomers to produce the exact degree of hardness, tensile strength, compression set, volume change and flexibility you require. Temperature resistance, with various materials, ranges from —100° to 500°F., and compatibility with an equally broad range of fluids, gases and solids, including petroleum base fuels and synthetic hydraulic oils can easily be achieved.

Whether you specify critical tolerances, exact concentricity or flawless bonding—the more reason to assign full responsibility to C/R Sirvene engineers. They'll assure the absolute uniformity and quality of your diaphragm straight through production. Define your diaphragm problem to us and see how we can help.

Write for your copy of the illustrated Diaphragm Bulletin SD-100.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1293 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario. **Export Sales:** Geon International Corp., Great Neck, New York.
Other C/R Products: *C/R Shaft and End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears*

SIRVENE C/R DIVISION
CHICAGO RAWHIDE

Write in No. 81 on Reader Service Card at start of Product Preview Section

chart it...
see it...
and decide instantly!

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STANDARD CHARTS... over 15,000

Read the pulse of heat, flow, pressure... whatever vital stream you check, whatever "make" your meter is, you'll act fast with facts on technical charts... write NOW for info!

"Special" Charts... fit your need!

Rocket "go or no-go" charts... whatever chart design you need, call us... we'll modify, or start from scratch to fit your needs exactly... send for "Special" data!

TECHNICAL SALES CORPORATION

189 Van Rensselaer Street • Buffalo 10, N.Y.

representatives for Technical Charts Inc. and Staebler & Baker, Inc.

Subsidiaries of Graphic Controls Corporation

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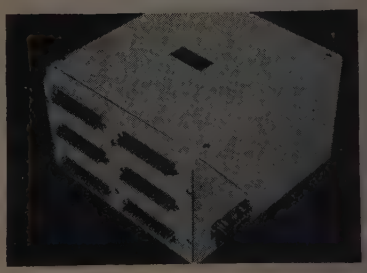
CAPACITORS *for high temperatures*

Manufactured of non-strategic materials, the type E-315 capacitors have completed qualification testing of 1000 hours at maximum temperature and rated voltage, says **Scintilla Division, Bendix Aviation Corp., Dept. S/A, Sidney, N.Y.** Temperature ranges are from –55 to 315 C. Capacitance values range from 0.05 to 4.0 microfarads at 600 VDC, with higher voltage available.

The capacitor features no-voltage derating, low capacitance and power factor variation environmental resistance, hermetic sealing, rugged construction, minimum size and weight, and high altitude operation.

Write in No. 156 on Reader Service Card

SAMPLING SWITCH offers stabilization



Model 108 A, a high-speed sampling switch, is designed for sequential drift stabilization of up to 83 high gain dc amplifiers, says **General Devices, Inc., Dept. S/A, Box 253, Princeton, N.J.**

The unit has two poles, 170 contacts per pole, or 85 non-shorting channels per pole, and a removable cover for inspection while in operation. The switch is supplied with a 110 V, 60 cps, single phase, synchronous motor, which drives the rotor at about 3 rps. It is 10x10.38x 6.31 in. The entire assembly is in plug-in form.

Write in No. 157 on Reader Service Card

PRESSURE TRANSDUCER is very accurate

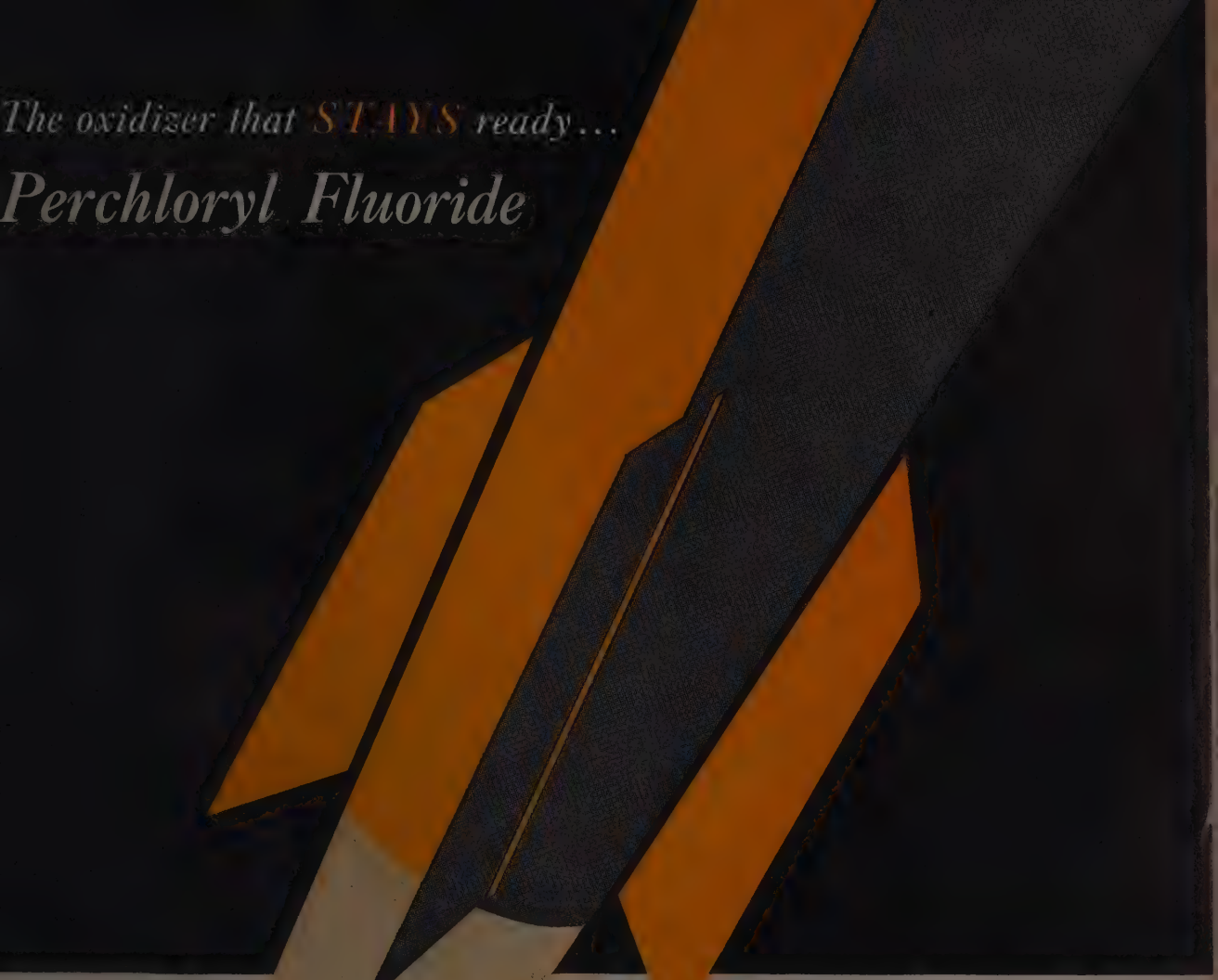
Model 451212 Pressure Transducer achieves 2,000 wire (0.05%) resolution and accuracy within one per cent of reading, says **G. M. Giannini & Co., Inc., Dept. S/A, 918 E. Green St., Pasadena, Calif.**

Precise static and dynamic balancing of the uniquely designed mechanism results in a combined linearity, hysteresis, and repeatability error of one per cent of reading or less. The instrument is available in pressure ranges from zero to ten through zero to 50 psi absolute, differential, or gage.

Write in No. 158 on Reader Service Card

more on page 220

Write in No. 85 on Reader Service Card→



Stable, storable, superior performance

Pennsalt "PF"® (Perchloryl Fluoride—ClO_3F) delivers high oxidizing power when it's needed, today or years from now. It's stable, noncorrosive, hypergolic but not incendiary in ordinary handling operations . . . can be permanently stored in liquid form without refrigeration. "PF" is easy to handle without undue hazard to personnel or support equipment. It gives high specific impulse, superior performance with a wide variety of fuels. "PF" is available in ton quantities for shipment in the U.S.

SPECIFIC IMPULSE

System	O/F (lb. per lb.)	Specific Impulse (second)	Condition
PF—Hydrazine	1.1	274	600# frozen
PF—UDMH	2.55	273	600# frozen
PF—JP4	4.03	255	600# frozen

Write for complete technical data on "PF"

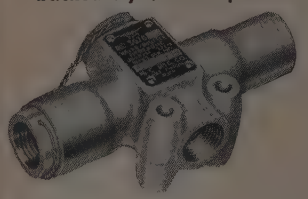
Commercial Development Department 965, Technical Division
PENNSALT CHEMICALS CORPORATION
Three Penn Center, Philadelphia 2, Pa.

Pennsalt® Chemicals
ESTABLISHED 1850

MC *hydraulic*

SHUTTLE VALVE

Lightweight . . . compact . . . backed by solid experience



Designed for tomorrow's usage, at temperatures from −65°F to +275°F. Design and manufacture of precision hydraulic and pneumatic valves, fuel pumps and air compressors has been the specialized activity of M.C. Mfg. Co. for many years. Call on our backlog of solid experience for built-in reliability in components for your applications.

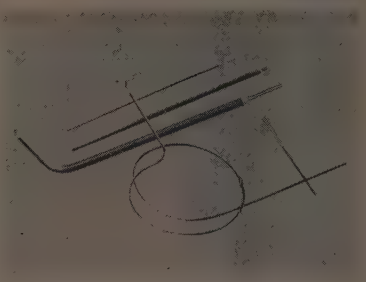
Specifications

FLUID: Hydraulic and air or nitrogen
PRESSURE: 3000 psi
TEMPERATURE: −65°F to +275°F
OUT PORT: Regular or Banjo
WEIGHT: .34 lb.

M.C. MFG. CO.
P.O. Box 126 • LAKE ORION, MICH.

Write in No. 82 on Reader Service Card

SWAGED ASSEMBLIES *are rugged*



This line of swaged thermocouple and electric assemblies consists of thermocouple or other electrical wires surrounded by a ceramic insulation and encased in a metal sheath. The sheath is swaged in a machine, crumbling and compressing the ceramic insulation so that it forms a completely tight seal around the wires. These assemblies can then be coiled or bent in any shape without damage to the insulation, says **Advanced Dynamics, Inc., Dept. S/A, 16321 Rockside Rd., Maple Heights, Ohio.**

These assemblies are said to give exceptional results in applications where corrosion, high pressure, severe vibration, and extreme temperatures are present.

Write in No. 159 on Reader Service Card

OHMMETER *with automatic ranging*

This 5-digit ohmmeter consists of an EI universal power module and a resistance switch module. The Model DOA-500 ohmmeter is accurate to 0.01% plus one digit from 000.01 ohm to 9.9999 megohms.

Average readout time is only 1.5 seconds, says **Electro Instruments, Inc., Dept. S/A, 3540 Aero Court, San Diego 11, Calif.**

Write in No. 160 on Reader Service Card

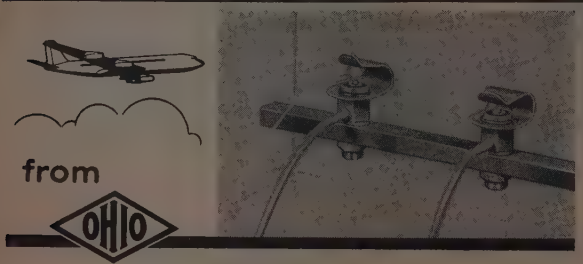
AMPLIFIERS *for wide frequency ranges*

The Model 45 transistor amplifier is a completely transistorized decade amplifier with continuously variable gain. A gain of 100 is available over a frequency range from five cps to one mcps, says **Zacharias Electronics Corp., Dept. S/A, P.O. Box 172, Livingston, N.J.**

The Model 108 quiet amplifier is an ultra low noise instrument which has a gain of 100 over a frequency range from one cps to one mcps. The equivalent input noise is 1.5 microvolts maximum for a 10 kilocycle bandwidth anywhere between 10 cps and one mcps, and 4 microvolts for a 100 kilocycle bandwidth.

Write in No. 161 on Reader Service Card

more on page 222



a new passenger jet aircraft

EMERGENCY DECOMPRESSION FLOW CONTROL VALVE

A compact, lightweight valve for installation in the emergency oxygen compartment. Valve stands 1⅛" above the manifold and is ¾" in diameter. Total weight is 0.8 oz. Can be individually or manifold mounted.

Valve is actuated when mask is removed from compartment by the passenger. It can be quickly and easily reset. Flow characteristics conform with altitude requirements.

For complete data and free engineering aid from specialists in aviation oxygen systems, please write to: Aviation Department.

OHIO *Ohio Chemical*

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
Madison 10, Wisconsin
(A Division of Air Reduction Company, Inc.) AIRCO

Write in No. 83 on Reader Service Card

rotary multipole switch

meets Specification MIL-S-6807

- *8 contact positions.*
- *Up to 6 sections, or poles.*
- *Unlimited or limited rotor movement by moving two stop screws.*
- *Electrical ratings: 5 amp. 28 v. d-c, resistive. 2.5 amp. 28 v. d-c, inductive. 2.0 amp. 28 v. d-c, lamp load. 5.0 amp. 115 v. 400 cps, resistive. 2.0 amp. at 50% power factor.*

The ESCO Type AF rotary multipole tap switch is designed to meet Specification MIL-S-6807. Rotor movement can be changed from unlimited to limited (2 to 8 positions) by placement of two stop screws in the rear plate.

Write today for Bulletin 7.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88, Massachusetts

Write in No. 84 on Reader Service Card

Blanketing the high temperature field

Close control is exercised over every step in the production of HAYNES alloys. This electric arc furnace is part of the modern mill set-up maintained at HAYNES STELLITE.

A fairly ambitious claim! Yet we can prove that HAYNES alloys do exactly that . . . all the way up to 2000+ deg. F. Here's why. There are 12 HAYNES high-temperature alloys. Among them you will find the right combination of properties to handle any heat condition. For example, HASTELLOY alloy X has remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 is strong and resists stresses, oxidation, and carburization up to 2000 deg. F. HASTELLOY alloy R-235 is outstanding in the 1500 to 1750 deg. F. range. And this is only part of the story. All 12 HAYNES alloys are *production* alloys and are readily available. Some of them are vacuum melted; some air melted. Some are cast, some wrought, and some are produced in both forms. For the full story, write for literature.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

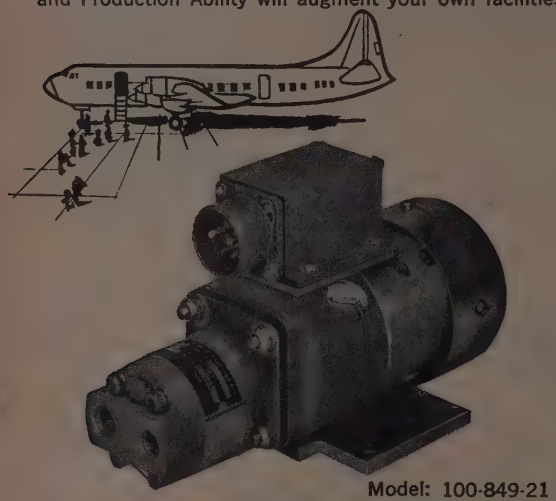
Write No. 87 on Reader Service Card at start of Product Preview Section

MOTOR DRIVEN HYDRAULIC PUMP

Assures Dependable Power for Integral Loading Steps on Lockheed Prop-Jet Electra

Model 100-849-21 has very successfully met military and commercial aircraft requirements of long life and dependability. This model is representative of a series of similar units designed and developed by Great Lakes to satisfy special requirements.

Great Lakes can save you time and money by incorporating existing units in your design plans at an early stage. You will find that our Engineering, Designing, Testing and Production Ability will augment your own facilities.



Model: 100-849-21

SPECIFICATIONS:

CAPACITY....0.2 GPM minimum at 3,000 PSI outlet.
DUTY CYCLE.....Continuous at 3,000 PSI
LIFE.....500 hours per Mil-P-5954A.
WEIGHT.....7.9 pounds.
CURRENT.....30 Amps. Maximum at 3,000 PSI and 26 Volts, D.C.

Some of the complete line of products designed and manufactured at Great Lakes

Pneumatic RELIEF VALVE | *Fuel* PRESSURE REGULATOR | *Water Alcohol* MOTOR DRIVEN PUMP | *Hydraulic* RELIEF VALVE

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES
MANUFACTURING CORPORATION
4223 Monticello Boulevard • Cleveland 21, Ohio
Write in No. 88 on Reader Service Card

VOLTAGE REGULATORS *are lightweight*

This series of five-watt rated (without heat sink) silicon zener voltage regulators operate in the range from 24 to 160 V, says **International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif.** The style HZ silicon rectifiers provide low dynamic resistance over a range from −65 to +165 deg C.

The matched zener diodes are mounted in an oil-filled housing that provides low thermal resistance. Each junction is hermetically sealed.

Write in No. 162 on Reader Service Card

COMPOUND *for microwave use*

This termed polycrystalline yttruim-iron garnet ($Y_3Fe_5O_{12}$) compound is a relatively high-density, non-porous material consisting of tightly bonded sintered crystallites whose crystal structure is identical with that of natural garnet, according to **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.**

This compound is available in sample quantities for use in non-linear electronic devices. Since the substance has a narrow line width, use in the 10-kmc frequency region is possible. In addition, operation at one kmc and below is feasible. The finished material is easily ground to any size and shape, has zero-watt absorption, and a density greater than 96% theoretical. Typical characteristics include: saturation flux density, 1800 gauss; line width (x-band), 60 oesteds; Curie temperature, 300 deg C.

Write in No. 163 on Reader Service Card

OSCILLATOR *is dual-channel*

Model 956 dual-channel voltage-controlled oscillator includes extended subcarrier frequencies up to 250 kc, with two channels having separate plug-in center frequency and deviation networks, says **Midwestern Instruments, Dept. S/A, 41st & Sheridan Sts., Tulsa, Okla.**

The unit produces carriers that are frequency-modulated by signals in the ±2.5-V range. Center frequencies covering all IRIG channels are available with the plug-in units.

Write in No. 164 on Reader Service Card

VIBRATION GENERATOR *tests structural life*

Model 390 A is a general-purpose unit for testing electronic equipment for fatigue and structural life through the use of induced vibration forces. For vibration analysis on prototypes, field conditions are exactly simulated, says **Solartron, Inc., Western Div., Dept. S/A, 10761 Burbank Blvd., North Hollywood, Calif.**

The unit operates as an electrodynamic shaker driven by a variable frequency power oscillator and amplifier. Vibration is effected by a moving coil in a magnetic field. Mechanical vibration is induced by synchronism with the frequency of current supplied by the coil.

Write in No. 165 on Reader Service Card

SILICON RECTIFIER *rated for 150 deg C*

Type TM 155 is a silicon rectifier with 1500-V, 400-ma ratings at 150 deg C. It is the first rectifier rated for 150 deg C performance at these high voltage and current levels, says **Transitron Electronic Corp., Dept. S/A, Wakefield, Mass.**

The unit is hermetically sealed in the standard 7/16-in. hex package and resists shock, vibration, and environmental changes.

Write in No. 166 on Reader Service Card

more on page 224

erver of Peace . . .

ATLAS

Air Force "Sunday Punch"

Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.

Introducing

a new line of

PRESSURE SWITCH/ TRANSDUCERS!

- *For Aircraft, Missile & Rocket Applications*
- *8 Pressure Ranges, covering 0.5 to 4,000 psi*
- *Available with Optional Vibration Isolator*
- *Qualified to MIL-E-5272A Specifications*
- *External Pressure Setting Adjustment*

The new Haydon 1500 Series Pressure Switch/Transducer weighs only 6 ounces—yet operates accurately at up to 4,000 psi! Interchangeability of internal modular components permits use of the same small, rugged housing over the complete pressure span from 0.5 to 4,000 psi.

This environmentally-sealed unit is designed for use in all types of pressure systems . . fuel, hydraulic, oil, pneumatic, chemical and gas. The entire assembly is resistant to corrosive operating media, including water-alcohol solutions, nitric acid and hydrogen peroxide, among others.

Write now for the new Catalog giving complete data on the Haydon 1500 Series Pressure Switch/Transducer.

HAYDON Switch INCORPORATED
WATERBURY 20, CONNECTICUT

Write in No. 89 on Reader Service Card

FILTER for ATC use

This unit is a bandpass-band-suppression filter for simultaneous ATC transmissions on adjacent channels in the lower range from a single antenna, says **Microphase Corp., Dept. S/A, Box 1166, Greenwich, Conn.**

Channels are separated by better than 30 db. Less in the pass frequencies is less than one decible. Filters with similar, as well as more complicated, notch valley characteristics in other ranges are available on special order.

Write in No. 167 on Reader Service Card

SUBCARRIER DISCRIMINATOR for IRIG Channels

Model 951 subcarrier discriminator is designed to include extended frequencies to 250,000 cps and outputs to 25,000 cps to meet future data system requirements, says **Midwestern Instruments, Dept. S/A, 41st & Sheridan Sts., Tulsa, Okla.**

The unit primarily converts intelligence in the form of frequency-modulated subcarriers to output voltages capable of operating most recording instruments. Channel frequencies and intelligence cutoff frequencies are determined by front plug-in units. The instrument permits use of very high frequency vibration data, triple FM, and high sampling rate data channels. Any standard frequency in the IRIG Telemetry Standards range is available from stock. Frequencies above and below IRIG standards are available on special order.

Write in No. 168 on Reader Service Card

EPOXY COMPOUND resists thermal shock

This Epoxylite #2151 compound offers extreme resistance to thermal shock, withstanding cycling to —90 deg F without failure, says **The Epoxylite Corp., Dept. S/A, P.O. Box 3397, El Monte, Calif.**

The compound has low viscosity at room temperature, long pot life, and temperature cures as low as 115 deg F. Potted units have wide safety-factor margin for —65 deg F tests required by military specifications.

Write in No. 169 on Reader Service Card

DELAY LINES are variable

Each unit in the Model 1R continuously variable delay lines is hermetically sealed and offers infinite resolution, says **Digitronics Corp., Dept. S/A, Albertson Ave., Albertson, N.Y.** The characteristic impedance is 250 ohms, but higher values are available.

The units have rise times of 0.06 μsec and a maximum attenuation of 1 db. Delays ranges are from 0.18 up to 0.62 μsec. The lower ranges have a case size 1x1¼x7¾ and the upper ranges of 1x1¼x10 in.

Write in No. 170 on Reader Service Card

TIME DELAY RELAY meets Mil spec

This versatile semi-conductor device performs programming functions in missile ground support equipment, operating military systems output relays with outstanding accuracy and reliability, says **Voi-Shan Mfg. Co., Dept. S/A, 8463 Higuera St., Culver City, Calif.**

With a high speed of action, the time delay resets itself instantly. Delay is from 60 millisec to 600 seconds. Accuracy from —62 to 72 deg C is ±4% at 28 V dc. Dimensions are 2x3x2 in., weight is 10 oz.

Write in No. 171 on Reader Service Card

more on page 227

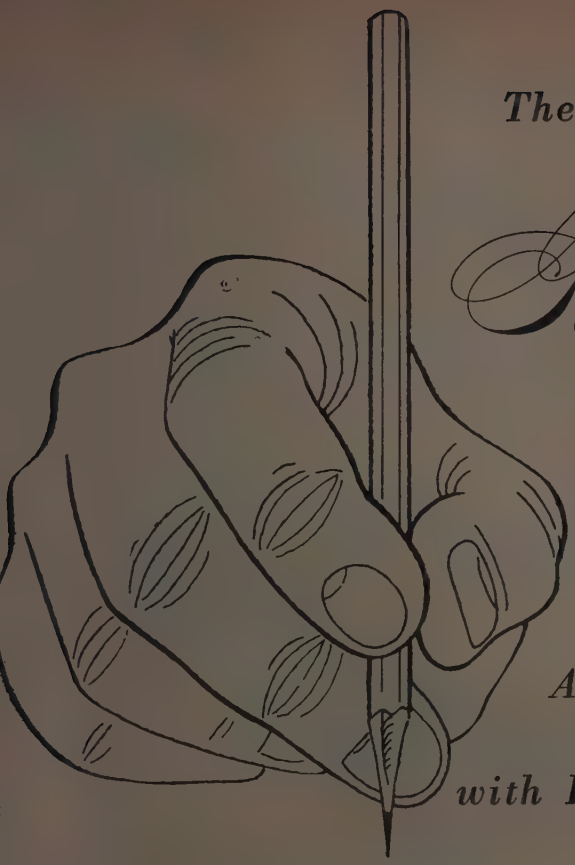
The Hand with the

Golden Touch

uses

A.W.Faber-CASTELL

with Black Gold Graphite



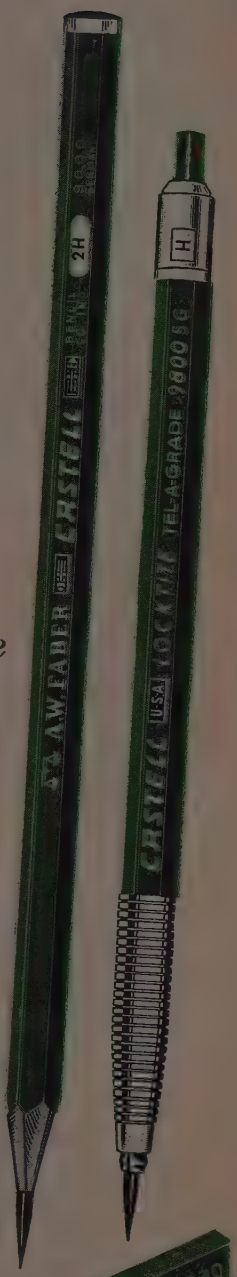
Who are the men with the "golden touch"? They are the architects turning out attractive renderings and perspectives; engineers drawing plans of extensive projects; designers creating bold new shapes and forms, and draftsmen making meticulous drawings and tracings.

The one thing that distinguishes so many of them is their use of our A.W.FABER-CASTELL, the drawing pencil with the Black Gold Graphite that tests out at more than 99% pure carbon. CASTELL is truly worthy of their talents, because it is the perfect partner in their creation, helping to translate their grey matter into black matter.

These men will tell you that CASTELL is the finest pencil on earth. It has no smudgy, smeary foreign substances to give the false illusion of black. It's all pencil from tip to tip, a Pro's pencil.

Let CASTELL bless your fingers with the "golden touch" and give flight to your creative or interpretive imagination. It costs no more to use the world's finest drawing tools—imported CASTELL wood pencils in 20 uniform degrees, 8B to 10H, imported CASTELL leads and LOCKTITE TEL-A-GRADE holders with the bulldog grip. Order from your dealer today.

Choose from: #**9000** CASTELL Pencil. #**9007** CASTELL with Eraser. #**9800SG** LOCKTITE TEL-A-GRADE Holder with new functional spiral grip and degree indicating device. #**9030** CASTELL Refill Lead matching #9000 pencil in quality and grading, packed in reusable plastic tube with gold cap. Other styles and colors of pencils, holders and refill leads.



Castell Leads and Pencils draw on all surfaces, including Mylar-based polyester drafting films. Give perfect lines, easy to erase —excellent reproduction.

BACKED BY NEARLY 200 YEARS UNINTERRUPTED MANUFACTURING EXPERIENCE — SINCE 1761

FABER CASTELL

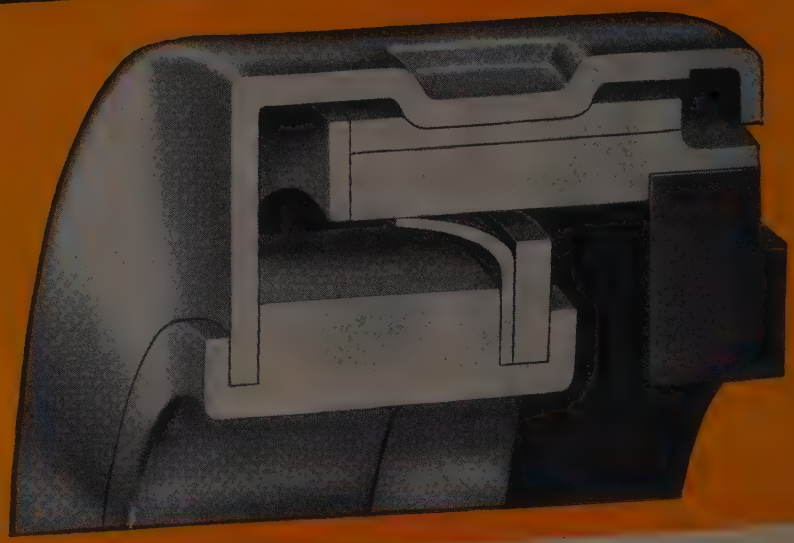
A.W.FABER-CASTELL Pencil Co., Inc.
Newark 3, N. J.

Copyright 1958

Write in No. 90 on Reader Service Card at start of Product Preview Section

NEW *Only Gits Met-L-Seal**

Seals at -65° to +850° F.



Now beyond the Research-Development Laboratory and into actual production — nothing like it on the market! Consider these exclusive design advantages, producing a built-in "missile reliability":

1. Hydraulic balance producing optimum sealing under both static and dynamic conditions — not always available in other all-metal seal designs.
2. Functions at temperatures, pressures and speeds in excess of capabilities of currently used organic materials — in minimum space required by aircraft-missile applications.
3. No internal fatigue. All components, except seal face, are made of various high-temperature alloy steels, each with the optimum combination of properties necessary to its function. (Exclusive Gits design makes Met-L-Seal operable at temperatures even higher than 850°, limited only by metallurgical progress in high-temperature alloy steels.) Positive guarantee against sudden complete operational failure and other drawbacks of synthetic-elastomer seals in extreme operating conditions.
4. No "shelf life" problems. No "cure-date" limitations as are necessary with synthetic-elastomer seals.

Send for new "Advance Catalog" or submit your seal problem to the experienced engineers of the Gits Aircraft and Missile Seal Division.

GITS BROS. MFG. CO.

Aircraft and Missile Seal Division

1866 S. Kilbourn Ave. • Chicago 23, Ill.

Specialists in Lubricating Devices and Shaft Seals for Almost Half A C

stainless steel
struction with
on graphite or
ic alloy
materials

COMPRESSOR-EXPANDER for speech

Called the Vari-Vox, this speech-time compressor or expander operates by repeating or discarding minute parts of audio signals (such as vowels, consonants, and pauses in speech) and retransmitting the signal without loss of intelligibility, says **Kay Electric Co., Dept. S/A, Maple Ave., Pine Brook, N.J.**

The frequency response of the unit is from 500 to 12,000 cps ±2 db. Both input and output impedance are 600 ohms. Recommended input signal is 0.2 V rms; output signal is 0.2 V rms. Compression is up to twice the normal rate in nine steps and expansion down to half the normal rate in nine steps.

Write in No. 172 on Reader Service Card

REACTOR SHIELDS for low frequencies

The telescoping-cylindrical Co-Netic subminiature reactor shield is designed for low-frequency magnetic and electrostatic shielding, says **Perfection Mica Co., Magnetic Shield Div., Dept. S/A, 1322 N. Elston Ave., Chicago 22, Ill.** The shields are designed basically for subminiature reactors using pot-type ferrite or laminated-core construction. The unit is insensitive to shock, non-retentive, and does not require periodic annealing.

The manufacturer also offers a dual-laminate Netic Co-Netic shield that gives improved resolution, thereby attaining maximum storage capacity in data storage tubes.

Write in No. 173 on Reader Service Card

BLOWER UNIT for electronic cooling

A series of tube-axial blower units have been designed for cooling electronic equipment. The Model MSA 4707 axial blower unit is six inches in diameter, four inches long, weighs 16 oz, and can deliver from 50 to 160 cfm, says **Torrington Mfg. Co., Air Impeller Div., Dept. S/A, Torrington, Conn.**

Variations in size and air output are available with either ac or dc motor.

Write in No. 174 on Reader Service Card

RF FILTER is low pass

Model 700 low pass RF filter is rated at 300 W C W and is pressure-tight, says **Adams-Russell Co., Inc., Dept. S/A, 292 Main St., Cambridge, Mass.**

The insertion loss is 0.3 db below 420 mc and 60 db from 750 to beyond 4000 mc. The VSWR is 1.3 below 420 mc in 5-ohm systems. The unit is 15 in. long and 2½ in. in diameter.

Write in No. 175 on Reader Service Card

DELAY GENERATOR is digitally adjustable

Model 218 A digital relay generator, a variable time interval standard, produces two accurately controlled time intervals. It is a direct slave to any beginning or synchronizing pulse, even though random, says **Hewlett-Packard Co., Dept. S/A, 275 Page Mill Road, Palo Alto, Calif.**

The range of delay times is digitally adjustable in one-microsecond steps from one to 10,000 microsecs, with provision for continuous interpalation between the steps. Overall accuracy of each delay is within ±0.1 microsec +0.001%. Jitter is less than 0.02 microsec. Time intervals or delays may be initiated by an internal rate generator from 10 cps to 10 kc or by external signal up to 10 kc.

Write in No. 176 on Reader Service Card

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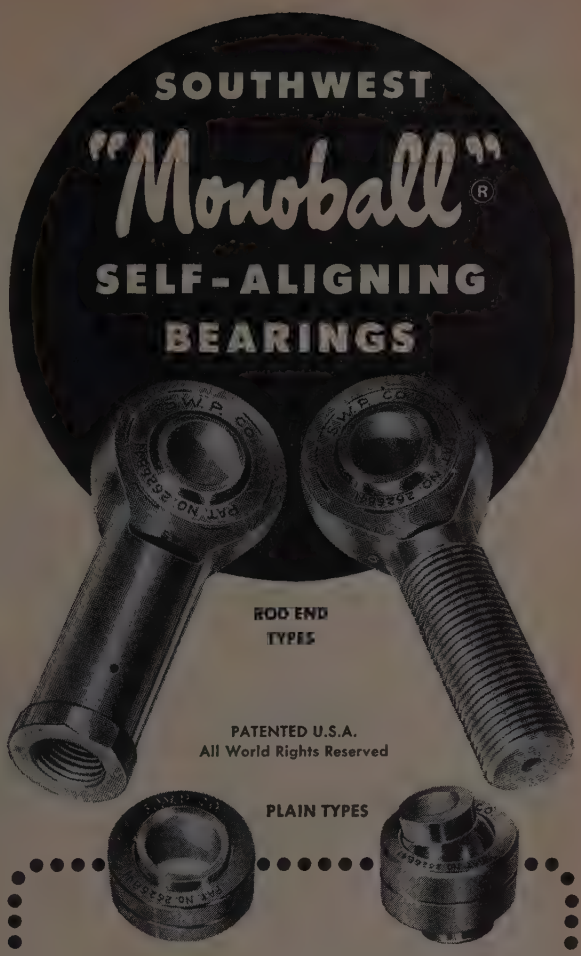


CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. S/A 59.

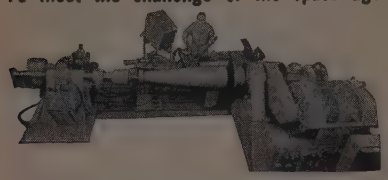
SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Write in No. 92 on Reader Service Card

←Write in No. 91 on Reader Service Card

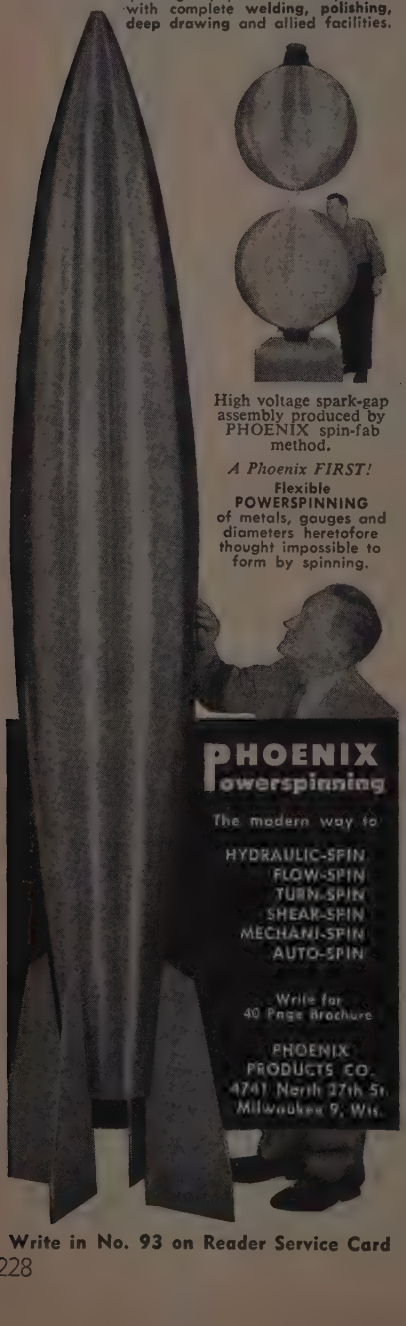
Announcing
COMPLETELY FLEXIBLE
PHOENIX
Powerspinning

To meet the challenge of the space age



Vanguard, Polaris, Talos, Jupiter and latest space projects utilize vital PHOENIX POWERSPUN components and assemblies.

Nose and tail cones, nozzles, venturi, bulkheads, guide vanes, exhaust hoods etc. are economically produced on Phoenix automatic, mechanical and manual metal spinning equipment in conjunction with complete welding, polishing, deep drawing and allied facilities.



High voltage spark-gap assembly produced by PHOENIX spin-fab method.

A Phoenix FIRST!
Flexible
POWERSPINNING
of metals, gauges and diameters heretofore thought impossible to form by spinning.

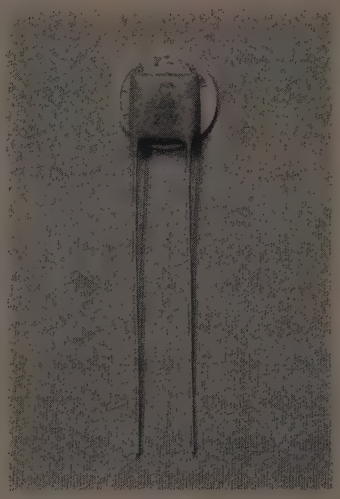
PHOENIX
Powerspinning
The modern way to
HYDRAULIC-SPIN
FLOW-SPIN
TURN-SPIN
SHEAR-SPIN
MECHANI-SPIN
AUTO-SPIN

Write for 40 Page Brochure

PHOENIX PRODUCTS CO.
4741 North 27th St.
Milwaukee 9, Wis.

Write in No. 93 on Reader Service Card

CAPACITORS have monolythic design



These monolythic ceramic capacitors, are said to be the latest development in capacitors for transistorized circuitry. A capacitance of up to .75 uf, 25 V dc, can be provided in a unit ½ x ½ x ⅛ in., says **Sprague Electric Co., Dept. S/A, North Adams, Mass.**

The capacitors are made by the alternate spraying of layers of a ceramic dielectric material and silver electrodes until the desired capacitance is achieved. The resulting homogeneous blocks can withstand a life test of 250 hrs at 150 per cent of the rated voltage and a temperature of 85 deg C. The units are available in seven uf ratings from .075 to .75.

Write in No. 177 on Reader Service Card

PREAMPLIFIER offers high performance

A dc coupling preamplifier, the Model 450-1300, for use with optical oscillographs, tape recorders, oscilloscopes, and other devices, offers high performance with either single-ended or balanced signals, says **Sanborn Co., Dept. S/A, 175 Wyman St., Waltham 54, Mass.** Frequency response is zero to ten kc, and linearity, ¼ per cent.

Front panel controls include sensitivity, position, attenuator, balance in-out switch, and input and output connectors, as well as others. Plus or minus zero suppression to 20 times full scale voltage is included. (The instrument is offered in a model that does not include zero suppression). A three-stage circuit has a cathode follower input and output, and a second stage push-pull transistor amplifier for overall gain. A 50-mv input produces one V under maximum output load conditions.

Write in No. 178 on Reader Service Card

more on page 232

Roebling Lock-Clad Aircord

Tested for outstanding service here

Roebling Lock-Clad—the preformed aircraft cable with aluminum tubing swaged around it—is designed and manufactured to go far beyond all standard specifications. Before specifying *any* aircord, check these facts about Roebling Lock-Clad:

1. It contributes to uniformity and sensitivity of control systems and consequent plane maneuverability.
2. Its construction reduces cable stretch to the absolute minimum and gives higher and constant AE values—throughout the entire load range.
3. It has 50 per cent better AE weight ratio than bare cord, thus permitting the use of smaller sizes.
4. Its use permits additional savings in weight through smaller, lighter controls, pulleys and supports.
5. Its smooth, clad surface fits perfectly through pressurized cabin stuffing boxes.

Roebling Lock-Clad Aircord is available in either galvanized or tinned carbon steel or in stainless steel, in all sizes. It can be furnished in complete assemblies with swaged terminals that develop the full catalog strength of the cord itself.

For full details on Roebling Lock-Clad, write Wire Rope Division, John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

ROEBLING

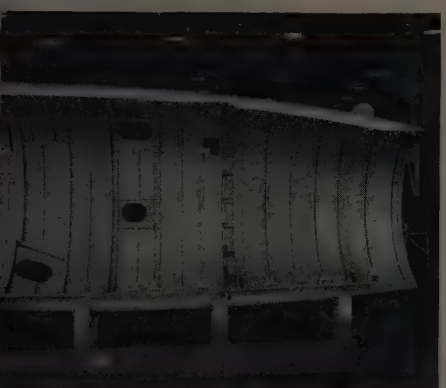
Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

Write in No. 94 on Reader Service Card

For improved strength/weight in the...

DC-8

1667 TITANIUM PARTS!



***Access door** on DC-8 engine assembly, fabricated entirely of titanium. Skin is .016" thick, ribs and longerons are .032" thick.*

Access doors on engine assemblies, pylon skirts, and hundreds of other structural parts on the Douglas DC-8 are fabricated from high strength, light weight, corrosion resistant titanium.

Mallory-Sharon service engineers have worked closely with Ryan Aeronautical Company engineers—a major supplier of parts and components for the DC-8. New high strength titanium alloys, improved methods of machining and forming, have been developed and employed. The result has been increasingly wide application of titanium's weight-saving advantages—*up to 57%* over stainless steel in many cases.

May we help *you* gain more benefit from titanium's unusual capabilities? Our experienced Service Engineering group is ready to assist you. Or write for new bulletin on Recommendations for Machining Titanium.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

Write in No. 95 on Reader Service Card at start of Product Preview Section

Successful heat exchange and heat insulation

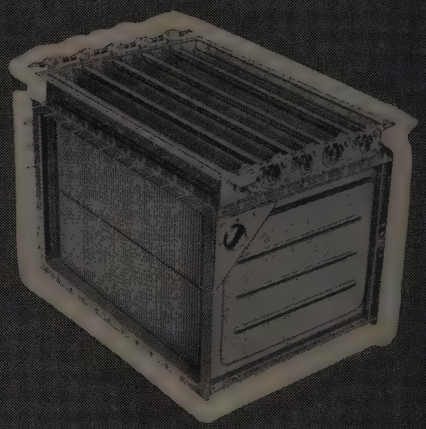
Success in our business doesn't merely mean the ability to manufacture, though we are extremely well equipped, even to the extent of having our own aluminum flux bath brazing plant.

Success to us, means the ability to solve problems; to produce something that will do a new job, or perhaps an old job in never-before-experienced circumstances. And then, of course, to make it a practical and economical proposition.

We have forty years experience and wide resources. If we can help you in any way with heat exchange and insulation equipment, please contact us. We are always at your service.

1

These thermal blankets are made of refractory fibre cased in .004 inch (.1016 mm) stainless steel. They are made-to-measure and are extremely light, the dimpled construction being responsible for their great strength. Specified for Rolls-Royce and Armstrong Siddeley jet and turbo-prop engines, these particular examples are shown fitted to the Rolls-Royce thrust reverser for the de Havilland Comet.



2

We design, manufacture and supply heat exchangers for many purposes in both aluminium alloy and stainless steel. This particular example is for the Vickers Vanguard's anti-icing system. Similar units are being supplied for the Fokker Friendship, the Bristol Britannia, the Armstrong Whitworth Argosy, the Vickers Viscount and the Handley Page Herald.

3

High pressure fuel-cooled oil cooler for high performance gas turbine engines. This unit is used in the Armstrong Siddeley Sapphire S.A.7.

Delaney Gallay LTD

Vulcan Works, Edgware Rd., London, N.W.2. Tel: GLAdstone 2201

We have now introduced Sealed Thermal Insulation Blankets for Civil Aircraft

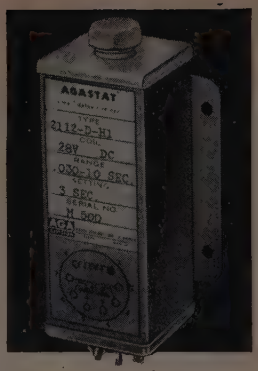
Write in No. 96 on Reader Service Card at start of Product Preview Section

RENÉ 41
fine WIRE
. . . almost too fine to see,
too versatile to believe!
• For use in the 1200°-1800° F range
• Tensile strength to 425,000 psi
From Cannon-Muskegon — a major move in special metals development! Now the amazing properties of René 41 are yours to utilize in *fine-wire form*. This new vacuum-melted, high-temperature product is just .0015" in diameter . . . half the thickness of a human hair. One ton could circle the earth three times, four tons would reach the moon!
Yet thin as it is, René 41 fine wire has unusual strength. Under cold reduction, tensile strengths to 425,000 psi have been obtained. And even at 1800° F it maintains high oxidation resistance, exceptional tensile and yield strength.
René 41 fine wire is currently being used in the form of screens, filters, cables, strainers and casings for high-temperature applications.
René 41 and other vacuum-melted high-temperature alloys are also available in sheets up to 48" wide x 120" long, and in thicknesses down to .010. Bar stock is available up to 3" in diameter, and foil down to .001 in thickness.
Our metallurgists will furnish any help or data you may desire. Write Cannon-Muskegon.
UltraMet
VACUUM MELTED ALLOYS FOR INDUSTRY
CANNON-MUSKEGON CORPORATION
2867 Lincoln Avenue • Muskegon, Michigan, U.S.A.
METALLURGICAL SPECIALISTS

Write in No. 97 on Reader Service Card at start of Product Preview Section

NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications



INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝". . . width—1 13/16". . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A30-319.

See the Agastat line at Booth 2244 at the I.R.E. Show.

AGA DIVISION **ELASTIC STOP NUT CORPORATION OF AMERICA**

1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

Write in No. 98 on Reader Service Card at start of Product Preview Section

For Safe Flexible Fluid Handling Lines— specify *CHIKSAN* SWIVEL JOINTS

FOR MISSILE FUELING

Swivel Joints and assemblies to handle cryogenic liquids and fuels in ground loading and topping hose. Assemblies developed to handle services ranging from −320°F to +600°F and pressures from 20" vacuum to 15,000 psi.

FOR GROUND SUPPORT EQUIPMENT

Loading arms and flexible transfer assemblies for handling Lox, N_2, He, JP Fuels, H_2O_2 and Hot Gases. Sizes range from ¼" to 16". Corrosion resistant steel, nickel, brass, aluminum, bronze and other metals available.

FOR GROUND HANDLING EQUIPMENT

Swivel Joints and assemblies to handle hydraulic, pneumatic, and fuel systems on launching vehicles and missile transporters. Units for rotation in 1, 2 or 3 planes in widest variety of metals, pressure and temperature available.

FOR AIRCRAFT SYSTEMS

Compact, lightweight package units in ¼", ⅜", ½" and ⅝" O.D. tubing sizes. Pressures of 28" vacuum to 4,000 psig. Temperatures of −65°F to +275°F. AN and MS standard end connections.

CHIKSAN COMPANY

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—BREA, CALIFORNIA

Send for informative Bulletin 558

59-41

Write in No. 99 on Reader Service Card at start of Product Preview Section

TEST SET measures crystals

The Type 390A-3 microwave crystal test set measures important characteristics of microwave crystals in mixer and detector applications.

Its ability to measure relative noise figure, relative sensitivity, match of crystal pairs, conversion loss, and noise temperature will give an indication of the important performance characteristics of microwave crystals, says **Airborne Instruments Laboratory Div., Cutler-Hammer, Inc., Dept. S/A, 160 Old Country Road, Mineola, N.Y.**

Write in No. 179 on Reader Service Card

ELECTRIC CONNECTOR protects cable wires

This miniature electric connector is designed for use with cable conductors to protect wires from abrasion and contaminants. The unit, Deutsch Model DM9708-S, was first developed for use in landing wheel assemblies, says **Deutsch Co., Dept. S/A, 7000 Avalon Blvd., Los Angeles 3, Calif.**

The connector is available in all Deutsch miniature shell sizes. An adapter for the appropriate AN3054 nut replaces the follower nut.

Write in No. 180 on Reader Service Card

POWER SUPPLY provides 2 amp

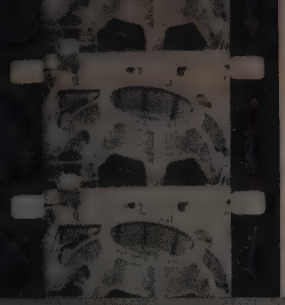
Model 62-124 all-transistor power supply provides full 2 amp current over a voltage range of 0.5 to 36 V dc, free from line transients and output overshoot, says **Dressen-Barnes Corp., Dept. S/A, 250 N. Vineto Ave., Pasadena, Calif.**

Regulation is 0.05% for a line voltage change from 105 to 125 V, and 0.05% from no load to full load. A forced air cooling system allows efficient operation up to 50 deg C. Model 62-124 has special fusing to prevent damage to transistors and measures 3½x19x16 in.

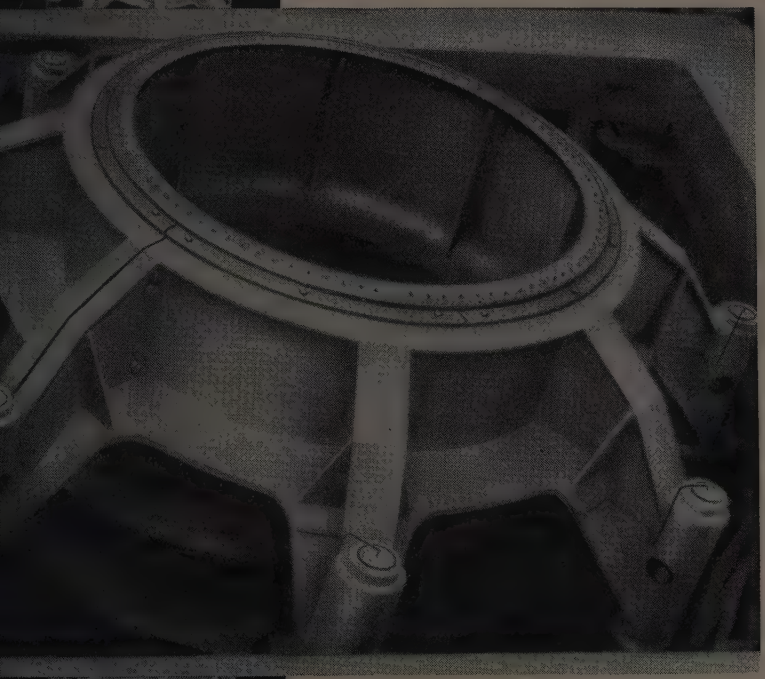
Write in No. 181 on Reader Service Card

more on page 234

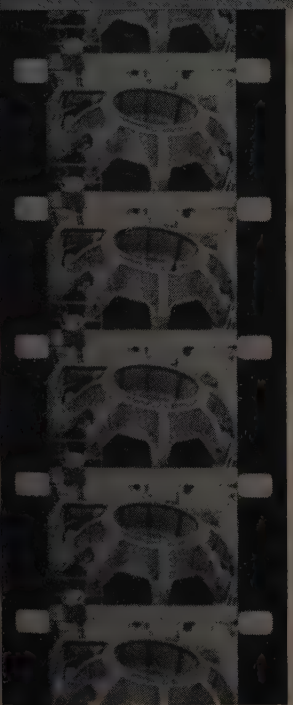
Write in No. 104 on Reader Service Card→



"Shaker" pitching



"Shaker" rolling



"Shaker"—Loewy's giant rocking horse—paves way for ballistic missile firing at sea

The giant ship motion simulator called "Shaker" has come to life. Designed and built by Loewy-Hydropress under prime contract with the U.S. Navy for its Fleet Ballistic Missile Program, the 40-ft.-tall rocking horse moves up and down, fore, aft and athwart under the electronic fingertips of a distant operator in a thick-walled concrete blockhouse.

"Berthed" at Cape Canaveral not more than 800 feet from the beach and nested in a 47-ft.-deep pit, "Shaker" performs all the important movements of a seagoing vessel. Sliding up and down, she imitates the vertical heave motion. Tilting port and starboard, she acts out rolling. Rocking forward and backward, she duplicates pitching. An intricate mechanism of giant gyrating joints makes these rock 'n' roll moves and their innumerable combinations possible. By proper setting, the typical behavior of an oceangoing vessel in seas ranging from calm to stormy can be recreated precisely by "Shaker."

Polaris, the Navy's Fleet Ballistic Missile, will soon be tested on "Shaker."

For creative engineering and design, research and development in your defense and industrial contracts, direct your inquiries to us at Dept. R-3

Loewy-Hydropress Division

BALDWIN · LIMA · HAMILTON

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

BALDWIN BLH LIMA-HAMILTON

A wide selection of the new Bristol stock 7/8" OD capsular elements is now available in pressure ranges from 15 to 350 psi.

These are the latest of Bristol's long-life, Ni Span C pressure sensing elements widely used in the aircraft and instrument fields. For applications requiring miniaturization, this new 7/8" OD is the optimum size. Nominal deviations from linearity of these precision miniatures is less than 1%.

Other Bristol stock capsular elements range from 1 13/32" to 2 11/32" OD and have a nominal deviation from linearity of less than 1/2% (deviation due to hysteresis of less than 1/4%). Normal operating temperature range is —65° to 300° F. . . . for higher temperatures to (550°) a slight 2% travel change may be expected.

Bristol has been manufacturing pressure sensing elements for 70 years. For further information on these capsular elements with outstanding linearity characteristics write for Bulletin AV2001: Aircraft Components Division, The Bristol Company, 150 Bristol Road, Waterbury 20, Conn. 8.54

BRISTOL FINE PRECISION INSTRUMENTS FOR SEVENTY YEARS

Write in No. 105 on Reader Service Card

GROUND STATION for telemetered data

This telemetry decommutation equipment can handle sampling rates from 24 to 3600 pps in both pulse amplitude (PAM) and pulse width (PWM) coding. Long term accuracy of better than ±0.5 per cent, including any system non-linearity and drifts, according to **Applied Science Corp. of Princeton, Dept. S/A, P.O. Box 44, Princeton, N.J.**

The unit also provides an undecommutated but thoroughly corrected output for convenience in digitizing. All basic M-series units can handle up to 100 channel signals, with 30, 45, 60, and 90 as standard channel configurations. Many optional units can be added, including signal simulators, meter readout units, pen recorders, monitor oscillographs, and digital voltmeters.

Write in No. 182 on Reader Service Card

TRANSPONDER TESTER is self-contained

This ATC L-band transponder test set performs all the testing features required to check out L-band airborne transponders manufactured to Arinc Characteristics 532band ANDB (AMB) 2.3 NAIB, says **Kearfott Co., Inc., Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.**

As a completely self-contained unit, it is portable, with a light aluminum chassis and carrying case with handles. Weight is 59 lb. Frequency range is 950-1220 mc. The repetition rate is 15-2000. Dimensions are 21x12x18 in. Standard relay racking is provided.

Write in No. 183 on Reader Service Card

MONITOR TEES for traveling wave tubes

These devices are used to monitor helix interception current in traveling wave tubes or to apply modulation to a traveling wave tube, says **T.E.M., Inc., Dept. S/A, 71 Okner Pky., Livingston, N.J.**

The monitor tees are available to cover octave frequency ranges from 250 to 12,000 mc. A dc blocking capacitance can be supplied in the rf output arm. They are available with Type N, TNC, or BNC connectors.

Write in No. 184 on Reader Service Card

CAPACITORS operate at +225 deg C

The Glennite Hi-T units are ultrathermic, glass-coated, ceramic capacitors designed for continuous operation at temperatures ranging from —60 to +225 deg C, says **Gulton Industries Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.**

The subminiature capacitors have silver leads and insulation resistances of 10,000 megohms at +25 deg C and 100 V dc.

Write in No. 185 on Reader Service Card

TESTER for SSB transmissions

Model SSB-3 sets up, adjusts, monitors, and troubleshoots SSB and AM transmission, says **Panoramic Radio Products, Inc., Dept. S/A, 514 S. Fulton Ave., Mount Vernon, N.Y.**

The instrument consists of a sensitive spectrum analyzer plus a stable tuning head and a two-tone generator. Self-calibrating and checking is also included. Preset sweep widths of 150, 500, 2000, 10,000 and 20,000 cps with automatic resolution. The unit has calibrated linear and logarithmic amplitude scales, a standard five-inch CRT, and two auxiliary outputs for chart recorder or large screen CRT.

Write in No. 186 on Reader Service Card

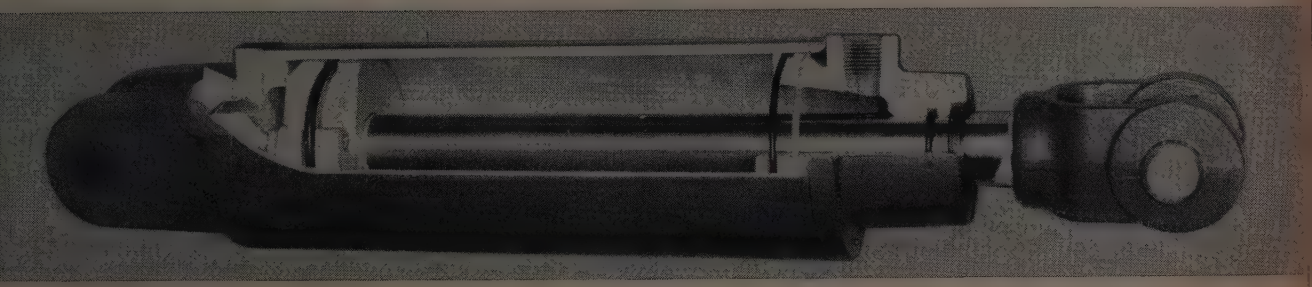
more on page 236

Write in No. 106 on Reader Service Card→

There's a HOLE lot of sense in this use of mechanical tubing

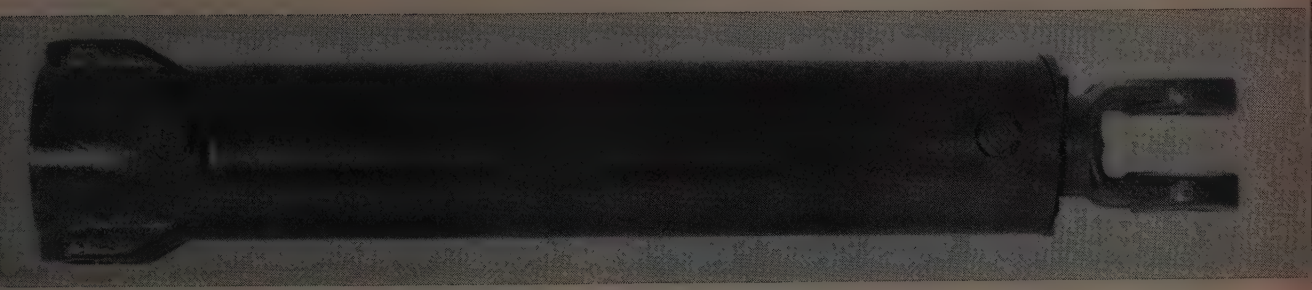
What we're talking about is USS Shelby Seamless Mechanical Tubing. Here's how Industrial Hydraulics Division, Cessna Aircraft Company uses it to boost life, simplify manufacture and lower costs in the hydraulic cylinders they supply to agricultural equipment builders. We quote from their letter to us:

"The cut-away cylinder is a unit we furnish to one of our many customers. This is a 3½" diameter, double-action cylinder used for mounting on pull-behind tools



such as plows, cultivators, and disc harrows. This cylinder uses your Shelby Seamless Mechanical Tubing with the I.D. bored to size and roller burnished to a finish of approximately six to eight RMS. The expected life of this cylinder is in excess of 300,000 cycles, operating at 1,500 psi hydraulic pressure.

"The other cylinder is furnished to another one of our customers, and is a 3¼" I.D. double-action cylinder with a 13" stroke. Used to raise and lower the platform of their self-propelled combine, it is similar to the cut-away cylinder



with respect to finish requirements and material for the barrel. The operating pressure is approximately the same and so is the expected service life of five years, or 300,000 cycles. Generally these cylinders may be serviced for additional use by merely replacing the seals.

"The severe field conditions these cylinders are subjected to are some of the most extreme to which cylinders could be exposed."

In critical mechanical applications like these, and in an almost endless number of fabrications that are essentially tubular in character, Shelby Seamless will ensure improved performance, finer appearance and economical production.

For Shelby Seamless offers more than just a pre-bored hole. It not only combines to an exceptional degree the qualities of strength, uniformity and dimensional accuracy but, in addition, is readily workable and has excellent machining properties. If you want to find out how it can be most effectively applied to your designs, contact your nearby Shelby Distributor.

And remember—USS Shelby Tubing is made by the world's largest and most experienced manufacturer of tubular products.

USS and Shelby are registered trademarks

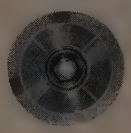
National Tube Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division • United States Steel Export Company, New York

MPB
MINIATURE PRECISION BEARINGS INC.

Need More "Room" in Package Assembly Design?

MPB special bearings integrated with shafts or housings are real space savers . . . reduce tolerance troubles as well as torque. Solve many other "package" problems. Details from MPB, Inc., 1403 Precision Park, Keene, N. H.



MPB helps you perform miracles in miniaturization
Write in No. 107 on Reader Service Card

DIGITAL VOLTMETER is a ac-dc

Model 402 digital voltmeter, an integrated ac-dc unit, provides 100 microvolts resolution in dc, one millivolt in ac. The numerals of the projection-type digital display are 1⅛ in. high and visible from a wide angle of view, says **KinTel Div., Cohn Electronics, Inc., Dept. S/A, 5725 Kearny Villa Rd., San Diego 12, Calif.**

The Model 402 consists of three units that can be mounted separately or together. In addition, it has a built-in printer drive. Input impedance is 10 megohms on all dc ranges at null; 10 megohm and 20 mmf on all ac ranges at null. DC range is 0.0001-999.9 V in four automatic ranges. AC range is 0.0001-999.9 V rms from 30 to 10,000 cps in three manually selected ranges. Automatic range is optional.

Write in No. 187 on Reader Service Card

KLYSTRON TRANSMITTER is stable

Model 50T transmitter uses an Eimac X 590 klystron with a power gain of 40 db and produces 18 kw of CW power and 50 kw of peak power at a maximum duty cycles of 0.4, says **Levinthal Electronics Products, Inc., Dept. S/A, Stanford Industrial Park, Palo Alto, Calif.**

The unit operates over 225-400 mc, has a pulse width of 50-10,000 microseconds and a pulse repetition rate of 0.1500 cps. Input power is 125 kva at 208 V, three phase, four wire, 60 cps.

Write in No. 188 on Reader Service Card

more on page 238

GABB FC-3500

MODEL NO.	TANK OPENING	O.D.	WEIGHT POUNDS	TYPICAL SERVICE	APPLICATIONS
FC-3510	1.5"	2.09"	.31	Synthetic oil	Military and Commercial Hydraulic Reservoirs
FC-3520	2.00"	2.80"	.69	Hydraulic oil	Military and Commercial Hydraulic Reservoirs
FC-3500	3.00"	3.75"	.80	Fuel, engine oil, water-alcohol	Military and Commercial Fuselage and Wing Tanks
37-3530	3.00"	3.75"	.719	Fuel, water-alcohol	Military and Commercial Fuselage, Wing and Drop Tanks, Fire Bombs
FC-3700	3.00"	3.47"	.456	Fuel, water-alcohol	Military Fuel Tanks
FC-4000	4.00"	4.62"	1.97	Fuel	Commercial Fuselage and Wing Tanks

The Gabb Adapter and Cap Unit, Tank Filler, is the first 3 inch assembly to successfully pass all the requirements of specification of MIL-C-7244 B (ASG). It is applicable to fuel, oil, water-alcohol and hydraulic reservoirs. This self-contained, flush mounted unit permits tank pressure relief by means of a lever action handle prior to removal of the cap from its adapter. Subsequent removal of the cap requires only a 35° rotation of the same handle. Write for free brochure No. 435.

GABB SPECIAL PRODUCTS Inc.
WINDSOR LOCKS, CONN.

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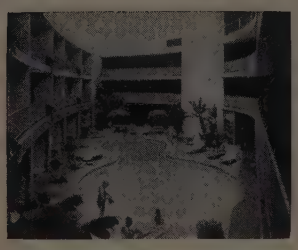
Convenient to the Los Angeles Aviation and Electronics Industry



BEVERLY CARLTON HOTEL
9400 W. Olympic Blvd.
Beverly Hills, Calif.
Tariff: $8 to $13 Sgl.
Double slightly higher

CAVALIER HOTEL
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★ Complimentary Breakfast ★ No charge for parking

WRITE FOR COLOR BROCHURES

OTHER LEE HOTELS
SKYWAYS HOTEL, L. A. AIRPORT
HOLLYWOOD-PLAZA HOTEL, HOLLYWOOD
HOTEL LAGUNA, LAGUNA BEACH
Bellevue Hotel, San Francisco • Flamingo Hotel, Phoenix

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THE REQUIREMENT:

A compact, fully portable hydraulic systems test stand for shore or shipboard ground support of Navy aircraft. Rugged dependability, minimum service and maintenance, plus simplicity of operation, are major requirements for this equipment designed to perform functional and operational tests of aircraft hydraulic system components and controls.

THE EQUIPMENT:

The Sun Aircraft Hydraulic Systems Tester, Model AHT-58, designed to occupy less operational and storage area than most units of comparable capacity (See Specifications). Completely self-contained with powerful axial piston type pump directly coupled to electric motor drive. Hydraulic system includes fluid reservoir, boost pump, low and high pressure filters and relief valves, compatible with fluids Specifications MIL-H-5606A and MIL-O-6083. Operating range: —20°F to 130°F (ambient temperature). All controls and instrumentation grouped on one panel for ease of operation and observation. Manufactured in accordance with Military Specification MIL-T-18062 (a) (Aer), Navy designation—XMA-75.

THE BUILDER:

For more than a decade, the Aeronautical Division of Sun has been a foremost designer and builder of electrical, electronic, hydraulic and pneumatic testing and ground support equipment for the Military and Industry. Sun's vast experience in these areas has been thorough and imaginative. For a fresh approach to your testing and support equipment problems, we invite you to consult with Sun's expert engineers.

If you do not have Sun's Catalog of Test and Support Equipment in your files, ask for it NOW

SPECIFICATIONS

Model: AHT-58 — Single System

Type: Class A — Electric Motor Driven, 40 hp

Power: 220/440v, 60 cycle 3 phase AC

Pump: Variable volume, adjustable compensator

Fluid Delivery:
19 gpm at 3400 psig
10 gpm at 5000 psig

Filters: 10 and 2 microns; element type

Overall Length: 80½ inches

Overall Width: 55¼ inches

Overall Height: 41½ inches

Weight (dry): 2700 pounds

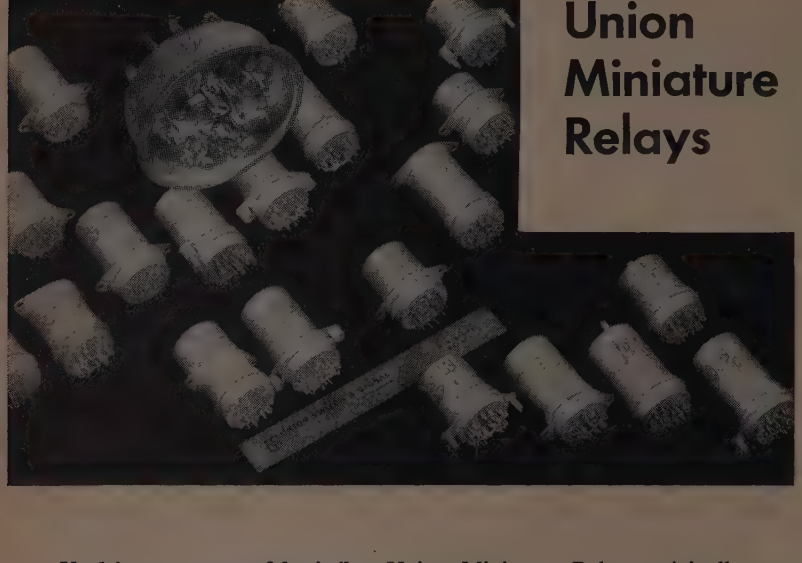
Sun Aircraft Hydraulic System Tester
Model AHT-58

Sun ELECTRIC CORPORATION

AERONAUTICAL DIVISION • HARLEM AND AVONDALE • CHICAGO 31, ILLINOIS

Write in No. 110 on Reader Service Card at start of Product Preview Section

Tops in reliability!



Union Miniature Relays

Used in seven successful missiles. Union Miniature Relays originally were developed for air-borne and guided missile electronic equipment; they meet or exceed the requirements of MIL-R-25018, MIL-R-6106C, and MIL-R-5757C. They are now being utilized in the following missiles: The Matador, Thor, Talos, Vanguard, Atlas, Titan, and the Jupiter C.

The excellent reliability and small size of the Union Miniature Relays have led to their use in traffic control systems, computers, resistance welders, and other equipment.

OUTSTANDING FEATURES

HI-LO CONTACTS—Permit high and low load handling in same relay. Dry-circuit contacts available for extremely low-level loads.

COIL RESISTANCE—In standard case, from 0.9 to 8750 ohms; in long case, from 1.6 to 13,000 ohms.

TEMPERATURE RATING—Class A −55 to +85°C; Class B −65 to +125°C.

AC OR DC—Nominal operating voltages from 1.5 to 160 volts, DC; 115 volts, 60 to 400 cps, AC. Built-in rectifiers in AC relays.

TYPES AND MOUNTINGS—6PDT or 4PDT; plug-in or solder-lug connections. All usual mountings.

SPECIALS—Slow-acting relays if you need a differential between operating time of various relays. Plate-circuit relays—operate on less than 8 milliamperes; double-coil relays—either coil operates relay. Write for complete information.

See us at Booth #2122-24 at IRE Show—Mar. 23-26

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

Write in No. 111 on Reader Service Card at start of Product Preview Section

SHAFT CONVERTER eliminates ambiguity

High resolution and the elimination of ambiguity are featured in a miniaturized ten-bit analog-to-digital shaft converter, says **Librascope, Inc., Dept. S/A, 808 Western Ave., Glendale 1, Calif.** The converter has applications in the computer control of automated industrial operations demanding precise, multi-positional reporting.

Ten-bit resolution is obtained with only a 3½-in. disc and yields up to 1024 position reports, which permits, for example, the control of linear machine feeds to within tolerances of .001 of the travel. The device may be modified to expand its capacitites to report on positional movements in three-dimensional parameters, and to follow fluctuations in fluid flows and temperature.

Write in No. 189 on Reader Service Card

NOISE-FIGURE INDICATOR is automatic

This Automatic Noise-Figure Indicator will make noise-figure measurements fully automatic. It is a single, integrated test instrument which with AIL's Type 70 (broadband noise generators) will continuously and directly indicate on its front panel meter the noise figure of a receiver under test, says **Airborne Instruments Laboratory, Inc., Dept. S/A, 160 Old Country Rd., Mineola, N.Y.**

The great value of the unit is said to lie not only in its speed and convenience but also in its ability to indicate during measurement the effect on noise figure of adjusting one or more interdependent receiver parameters. It eliminates point-by-point accumulation of data and assures a more accurate indication of noise figure because errors due to drift in receiver gain are eliminated.

Write in No. 190 on Reader Service Card

COMMUTATOR
is very accurate

This solid-state, multichannel electronic commutator has an input-to-output accuracy of one per cent or better, including linearity and offset factors, for any mixed source impedances up to 25 K, says **Applied Science Corp. of Princeton, Dept. S/A, P.O. Box 44, Princeton, N.J.** The sampling switch has a speed of zero to 1000 samples per sec, a life expectancy of 5000 hrs, and a temperature range of —60 to +80 deg C.

Development of only a very small back current (under one ua) during the time a channel is off eliminates the problem of transducer loading. The commutator will handle zero to five V input signals in all I.R.I.G. standard pulse amplitude and pulse duration sampling rates. Standard channel configurations are 30 and 45, including synchronization pulses. Power consumption is under three W.

Write in No. 191 on Reader Service Card

INVERTER
is very precise

A magnetic amplifier, silicon transistor control, and tuning fork control of 400-cycle output contribute to the precision of the Model 4617 rotary inverter, says **Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Texas.** The device, which is designed to power a missile's inertial guidance system, may also be used for manned aircraft and other applications.

The inverter delivers 750 va, operating from a 28-V dc input. Voltage is conrtolled to +0.2 per cent and frequency to +0.01 per cent. The 400-cycle output is held to better than +0.01 per cent over a temperature range of —55 to +71 deg C. Most of the 38-lb unit's components are encapsulated and will withstand the vibration requirements of airborne operations.

Write in No. 192 on Reader Service Card

more on page 243

Compact! Easy to Read! Union Data Display Indicators

Union Switch & Signal makes two types of electro-mechanical, DC-operated data display indicators: digital types, displaying 10, 12, or 16 characters on a wheel; and alpha-numerical types, displaying up to 64 characters on a MYLAR* belt. Character assignments can be furnished as required.

TRANSLATION Both Digital and Alpha-Numerical Indicators operate directly on binary codes on a null-seeking basis. This eliminates the need for external equipment for translation from binary to decimal code, as required with other display devices.

VISUAL READ-OUT Indicator packages are designed for quick, easy readability, even when indicators are mounted in rows.

INFINITE RETENTIVITY The indicators require power only during the response time, because they are of the null-seeking type. Once positioned, the indicators *retain* the data visually and electrically until a new code is transmitted.

ELECTRICAL READ-OUT The design of the decoding and control portions of the indicators provides electrical read-out of data in the same form as the input. The data can be read continuously or periodically without erasing the stored information.

USES These indicators can be used in the output of digital computers, in teletype receiving equipment, in telemetering systems, or wherever data needs to be displayed. Bulletin No. 1015 gives you complete information.

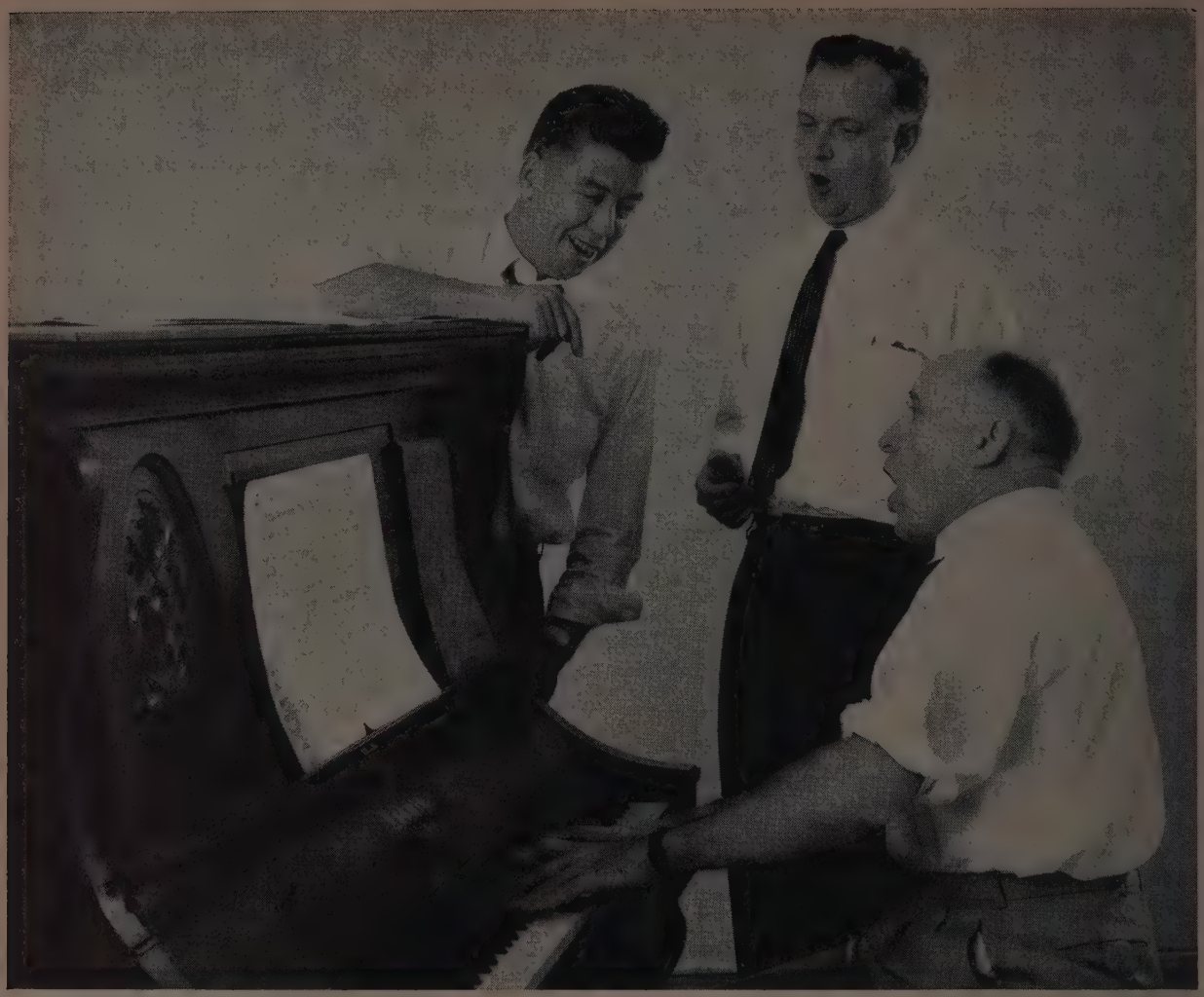
**Dupont's synthetic fiber*

See us at Booth #2122-24 at IRE Show—Mar. 23-26

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

Write in No. 112 on Reader Service Card at start of Product Preview Section



In Research—meet three men who get results

Dr. Stuetzer, Mr. Jones, Mr. Demorest work with the electron mirror microscope, a complex instrument which presents a picture of the electrical potential distributions on the surface of matter. The microscope was developed by General Mills for research and development work in solid-state and surface physics. It is the only one of its type in this country.

From high notes to high altitudes, harmony is the keynote of General Mills Research

Meet this harmonious trio of research scientists who spearhead progress in space technology at the Mechanical Division of General Mills. At the piano is Dr. Otmar Stuetzer, whose primary fields are physics and electronics research. Directly opposite him is Les Demorest, manager of atmospherics and measurements research. Sam Jones, standing to the left of the piano, is in charge of the section devoted to materials and mechanics research.

Scientists in our Research Department, like these three, help lay the groundwork for man's conquest of space. They work in harmony with each other and with the creative engineers and precision craftsmen who apply their findings.

Perhaps you can profit from teamwork like this. We'd like to work *with* you.

NEW BOOKLET RIGHT OFF THE PRESS tells and shows the many ways we serve industry and the military. Write for your copy. Address Dept. AA-2

MECHANICAL DIVISION General Mills

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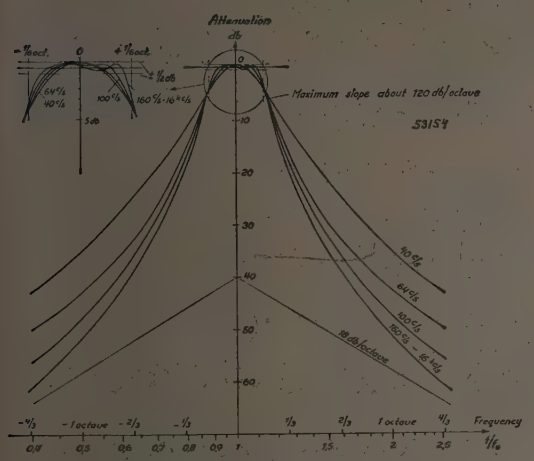
To wider worlds—through intensive research • creative engineering • precision manufacturing

Write in No. 113 on Reader Service Card at start of Product Preview Section

New . . . Bruel & Kjaer 1/3 Octave SPECTRUM ANALYZER

- *Analyzes Noise and Vibration in True RMS Values!*
- *Analyzes Complex Signals—14 c/s to 36,000 c/s.*
- *Analyzes Signals from 5 Micro Volts to 1000 Volts.*
- *Combines with the B & K Level Recorder for Automatic Analysis and Data Plotting.*



Detailed filter characteristics.

The new Audio Frequency Spectrometer Model 2110 features switch selection for either a true RMS, average or peak reading of analyzed data. The RMS indication is most frequently preferred for noise and vibration measurements because of its direct relation to the energy of the signal being measured.

The new model 2110 has thirty 1/3 octave band filters to extend the frequency range for complex signal analysis to be from 35 c/s to 36,000 c/s. Optional 1/3 octave filters may be added to extend the low frequency range down to 14 c/s. The spectrometer can be mechanically switched by the level recorder Model 2304 for automatic measurement and recording of spectrograms on frequency-amplitude calibrated chart paper.

Write now for complete information on B & K 2110!

Exclusive Franchised U. S. Marketing Agent for Bruel & Kjaer Instruments

Gentlemen:
Please send me information on the B & K Model 2110.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

B & K INSTRUMENTS, Inc.
3040 W. 106th STREET • CLEVELAND 11, OHIO • CLearwater 1-8430

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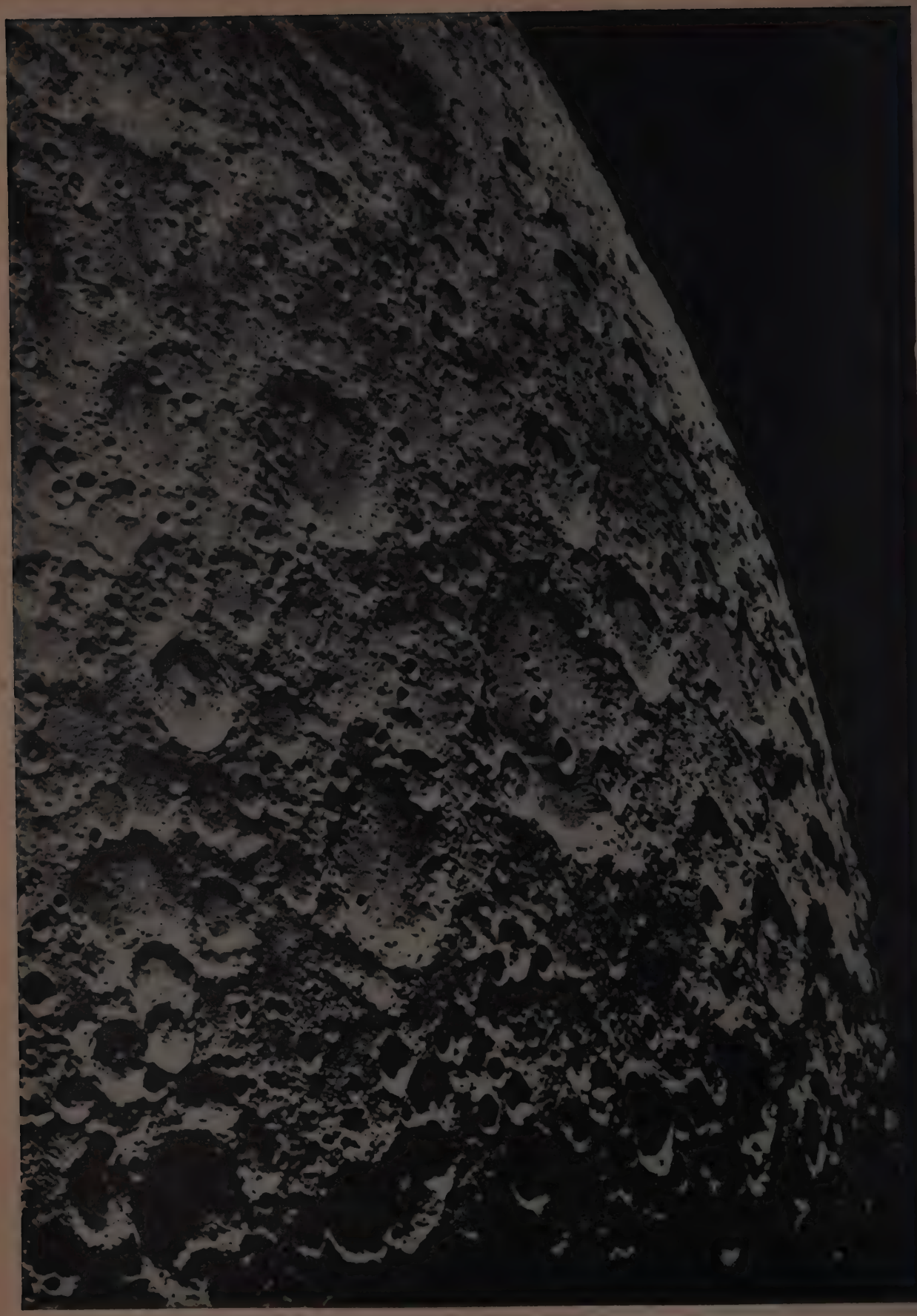


"THE MILITARY REQUIREMENTS FOR MOON BASE"
This is the title of one of four major proposals developed within the past 12 months by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; we could and can undertake such a project now — not in theory but in "hard" engineering design. In preparation for that inevitability, Martin already has built the capability for it. One important step was the creation of the Space Flight Division*, which is now directing Phase 1 of Project DYNA-SOAR.

*The Space Flight Division is one of the 7 divisions of Martin

MARTIN
BALTIMORE · DENVER · ORLANDO

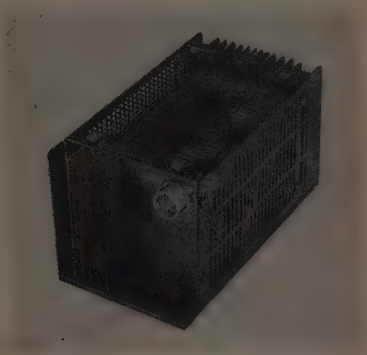
REGULATOR CIRCUITS are compact

This device combines in a single package a voltage reference (temperature compensated zener diode) and an amplifying transistor. According to **Transitron Electronic Corporation, Dept. S/A, Wakefield, Mass.**, this unit provides a combined temperature coefficient as low as 0.002% per degree C over a range of −55 C to +100 C.

Regulator circuits may now be designed with only one transistor, one "Ref-Amp," and four resistors.

Write in No. 193 on Reader Service Card

POWER SUPPLY is transistorized



This lightweight power supply provides closely regulated 28 vdc and 260 vdc with minimum size and maximum reliability, according to **Canoga Corp., Dept. S/A, 5955 Sepulveda Blvd., Van Nuys, Calif.** Designed for 400-cps power systems, radio interference and transient problems are well below minimum spec requirements. The unit weighs 4½ lb., and measures 7½x3 $13/16$x4 in.

The input voltages 200 vac 3ϕ, 320-480 cps with two outputs (28 vdc, 0-3a or 260 vdb, 0-150 ma) available. Ambient temperature is −55C to +55C mil specs are Mil-E-5400A, Mil-E-5272A, and Mil-I6181B.

Write in No. 194 on Reader Service Card

TRANSISTOR for high frequency and power

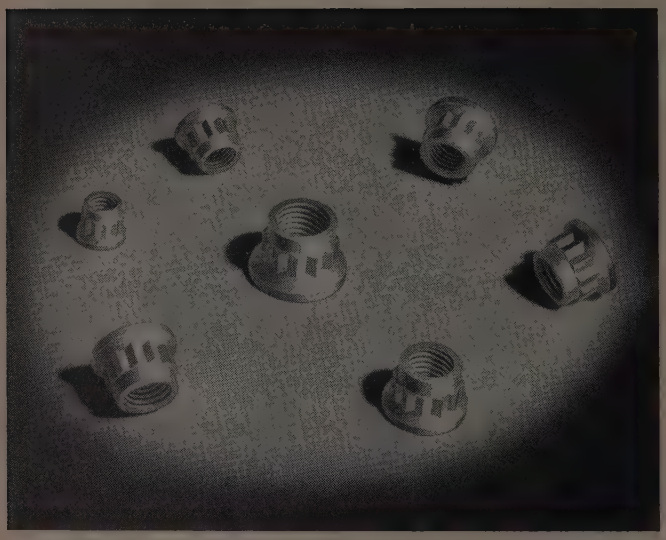
A diffused base germanium transistor provides 15 W of dissipation and has typical 12 Mc alpha cutoff frequency, according to **Texas Instruments Inc., Dept. S/A, P.O. Box 312, Dallas, Texas.**

Type 2N1046 is built specifically for use in horizontal and vertical cathode-ray tube deflection circuits and in computer core-driving applications. With an 80-volt collector voltage rating, this P-N-P transistor has low collector reverse current averaging 0.2 ma at 40 V and a low 0.75 ohm saturation resistance.

Write in No. 195 on Reader Service Card

more on page 246

New SPS 1200° F Featherweight Locknuts save you up to 57% in locknut weight



WEIGHTS OF FN-1216 AND COMPARABLE LOCKNUTS

(all weights expressed as pounds per 1000 pieces)

Size	SPS FN-1216	Competitive Locknut A	Competitive Locknut B	SPS 119 FW
#10-32	2.4	5.0	2.5	6.1
¼-28	4.0	8.0	4.1	8.6
5/16-24	6.3	13.0	6.5	12.2
3/8-24	9.4	17.0	—	16.4

New SPS FN-1216 Featherweight Locknuts provide over 150,000 psi tensile at 1200°F, weigh up to 57% less than any comparable nut. Thread pitch diameter is square with the bearing face of the nut within .003 in. when measured according to MIL-N-25027.

New SPS FN-1216 Featherweight Locknuts are designed for high-temperature structural applications on airframes, jet engines and missiles. They provide 200,000 psi minimum tensile strength at room temperature and over 150,000 psi at 1200°F. They are the lightest nuts available for their type of service, weighing up to 57% less than conventional counterparts. And because of their controlled dimensions they can be used with shorter bolts and installed closer to vertical bulkheads. This miniaturization permits additional weight savings.

The FN-1216 is the first lightweight locknut of its class to be fully documented for reliability by extensive service-simulating tests. These show that under conditions of cycling through 1200°F for 100 hours in the stressed condition with reapplication, the FN-1216 retains its locking action at least twice as long as any comparable nut. They also show a stress rupture life exceeding 23 hours at 1200°F under 100,000 psi loading.

FN-1216 locknuts are forged from AMS 5735 material and silver plated per AMS 2410. Thread pitch diameter is square with the bearing face of the nut within .003 in. when measured according to MIL-N-25027. The FN-1216 is the only standard high-temperature locknut held to this tolerance. Locking action is achieved by closing in the threaded collar at three points during manufacture. Standard sizes range from #10-32 through 3/8-24. For new Bulletin 2468, write SPS—manufacturer of precision threaded fasteners, including titanium. Aircraft/Missiles Division, STANDARD PRESSED STEEL Co., Jenkintown 54, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

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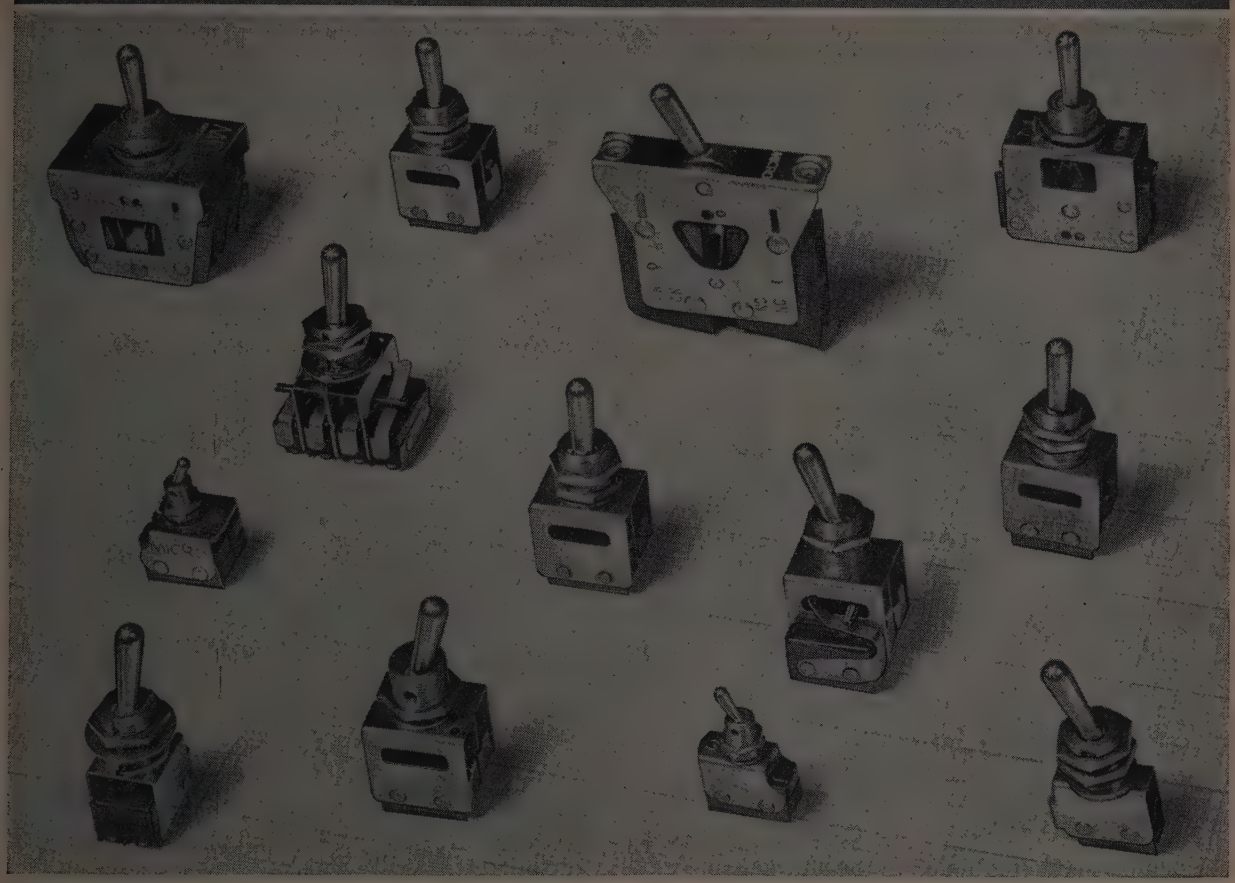
MICRO SWITCH Precision Switches



Compact "AT" toggle switch assemblies meet wide range of requirements in small space

The 13 toggle switch assemblies illustrated above represent a group of more than 100 similar compact assemblies designed to actuate from one to as many as a dozen miniature precision basic switching units. They find wide use in aircraft, mobile, marine, electronic, and all panel applications.

In this group are 2- and 3-position switches, in all combinations of contact arrangements . . . with either maintained or momentary lever positions. Within the group are switches for special requirements. For example, the switch at upper right includes an "electric memory" unit that indicates by a light or buzzer which circuit was last actuated. Other assemblies in the line feature pull-to-unlock levers, sealed levers, and hermetically-sealed basic switches.

All are manufactured with utmost precision, with consideration given to such important details as rigidity, positive "feel" and positive action, ease of mounting, good appearance, and long life.

"AT" toggle switch assemblies are described fully in Catalog 73. Assistance in switch application is available from the MICRO SWITCH Branch Office near you.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH PRECISION SWITCHES

Write in No. 116 on Reader Service Card at start of Product Preview Section

VERNIER POT
is three-decade unit

Type 81-A Rinco-Pot vernier potentiometer is a three-decade voltage divider using a Kelvin-Varley circuit, providing high resolution and very accurate voltage division, says **Rinco Inc., Dept. S/A, 7962 S.E. Powell Blvd., Portland, Ore.**

A single control knob operates either of two resistance decades. Three turns cover the full range—as against 100 on a helical potentiometer. The dial registers directly to four places with no possibility of parallel error. The unit is supplied with a standard resistance value of 10,000 ohms and with other values on special order. Full-scale resistance accuracy is ±0.05%, linearity is ±0.01%, and a resolution is 0.002%.

Write in No. 196 on Reader Service Card

INSULATION BLANKET
for hi-temp use

Aircon D-V, a thermal insulation blanket for air-conditioning ducting for aircraft and missiles was subjected to tests of salt water, oil, JP-4 fuel, and hydraulic oil with the result of the highest weight gain being only 0.92 per cent in JP-4 fuel. It did not corrode or deteriorate. It is also fungus and mildew resistant, says **Airconductors, Dept. S/A, 367 E. Olive St., Gardena, Calif.**

A 650 to 850 deg F, inside ducting temperatures, the outside temperature of this insulation blanket range from 220 to 244 deg F. It has withstood surface load depressions of 0.070 in. and accelerations up to 25 G's in vibration tests wtihout defect.

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more on page 249

THE TREND
IN DRAFTING ROOMS
THROUGHOUT
THE WORLD IS
TOWARD IMPERIAL,
THE WORLD'S FINEST
TRACING CLOTH

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When the design calls for an indicating gauge, specify the best—
MARSH
New catalog covers gauges for every need
MARSH INSTRUMENT CO.
Sales Affiliate of Jas P. Marsh Corporation
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Marsh Instrument & Valve Co. (Canada) Ltd.
8407 103rd Street, Edmonton, Alberta
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3501 Howard Street, Skokie, Ill.

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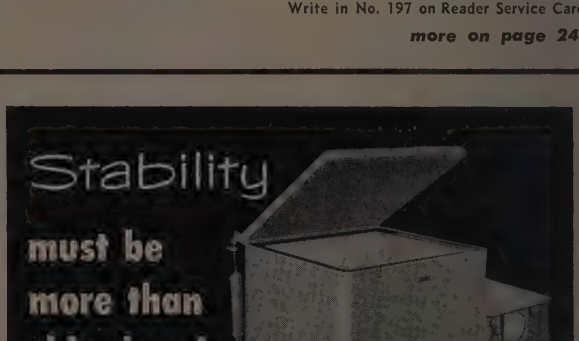

Cincinnati Sub-Zero insures maximum stability of metals . . . even at supersonic speeds!

MODEL 4SR-120-64
New 64 cu. ft. production unit brings 350 lbs. of AM-350 stainless steel per hr. from ambient to minus 120° F.

Speeds of thousands of miles per hour . . . murderous split-second temperature and altitude changes . . . today's aircraft, rockets and missiles survive an almost unbelievable assault in the vital race for preparedness.

Whether or not your products are involved in this "race", Cincinnati Sub-Zero production chilling or environmental test units can help them survive . . . produce completely stabilized steels that retain high-impact hardness and dimensional stability under toughest conditions.

Write us for Catalog and outline your needs for a no-obligation recommendation on a custom-designed unit.

CINCINNATI SUB-ZERO PRODUCTS
General Offices and Plant: 3930-VS READING ROAD, CINCINNATI 29, OHIO
Member, Environmental Equipment Institute

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on fabricating facilities for aluminum?

Let ALCOA'S JOBBING DIVISION Be YOUR Subcontractor!

WANT TO stretch your aluminum fabricating facilities, particularly during peak production periods?

THEN CALL on Alcoa's "custom-service for *manufacturers*"—the Alcoa Jobbing Division. From a single, tiny component to the most complex subassembly, consider Alcoa's Jobbing Division for any part of an aluminum fabricating job. In the field of aircraft and missile components, especially, Alcoa's facilities and experience are unmatched anywhere in the world.

COST . . . ? Frequently *less* than your own cost-accountants would report for a do-it-yourself job. For Alcoa *already* has the major facilities for production—plus the facilities and skills for tooling-up at rock-bottom costs.

WANT TO know more . . . ? Write Aluminum Company of America, 2027-C Alcoa Building, Pittsburgh 19, Pa., for 16-page booklet on the available facilities of Alcoa's Jobbing Division. Facilities at *your* service . . . for welding, rolling, brake-forming, bending, spinning, finishing, testing and other services. You'll be surprised how much Alcoa can help you *lighten* your load!

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch **"Alcoa Theatre,"** Alternate Mondays, **NBC-TV** and **"Alcoa Presents,"** Every Tuesday, **ABC-TV.**

Write in No. 120 on Reader Service Card at start of Product Preview Section

AN ASW SYSTEM... DISPLAY/AIRBORNE RECEIVER/SONOBUOYS

Anti-submarine warfare equipment designed, developed and produced by *The Magnavox Company*, in conjunction with the Navy Department, provides patrol aircraft with eyes that see underwater by day and by night. The AN/ASA-16 Display System, together with SONOBUOYS, AN/ARR-26 Receiver systems and other associated equipment provide aircraft with a clear picture of the ocean-depths below them. They are part of the continuing contributions of *The Magnavox Company* in aiding the U.S. Navy to combat the growing submarine menace.

MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.

PRODUCTS THAT SEE BY THEMSELVES

Magnavox

GIVES EYES TO NAVY ANTI-SUBMARINE WARFARE UNITS!

COMMUNICATIONS | RADAR | DATA HANDLING | ASW | MISSILES

THE MAGNAVOX CO. • DEPT. 50 • *Government and Industrial Division* • FORT WAYNE, IND.

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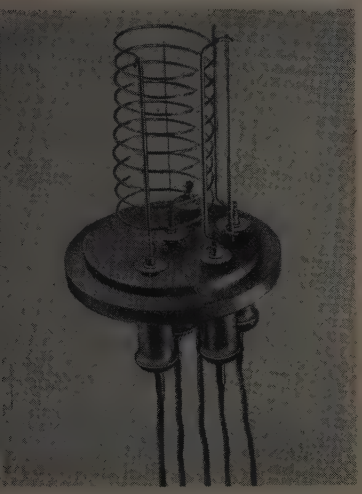
IONIZATION GAGE offers filament choice



This flanged, all-metal Bayard-Alpert ionization gage for use with all-metal or bakeout vacuum systems is available with either a non-burnout iridium filament (FG-200) or double tungsten filament (FG-200-T). These gages are ideal measuring devices in the high-vacuum region (1-micron and less) and in the ultra-high-vacuum region below 10^{-8} mm Hg, according to **Veeco Vacuum Corp., Dept. S/A, 86-P Denton Ave., New Hyde Park, N. Y.**

The helical molybdenum grid is outgassed by passing a current of about 10 amp through it. This will at the same time outgas the collector wire by radiation.

Write in No. 198 on Reader Service Card

CONVERTER for data processing

Model V 16-AD, a high-speed voltage-to-digital converter, is designed to meet rigorous linearity and accuracy specifications, says **Adage, Inc., Dept. S/A, 292 Main St., Cambridge 42, Mass.** This four-decimal digit unit has a relative accuracy at room temperature of 0.01% of full scale ±½ least digit ±200 mv. Relative accuracy will vary 5 ppm/deg C. The standard gas tube reference will normally maintain 0.01% accuracy for several hours. Long term drift is usually less than 0.03% per month. If a long term drift of 0.01% is needed, a reference supply is available at a slight additional cost.

Inputs are full scale—1, 10, and 100 volts. Input impedances are 1, 10, and 100 K, respectively. The unit mounts on RET MA relay rack and needs only 5¼ in. of panel space. space.

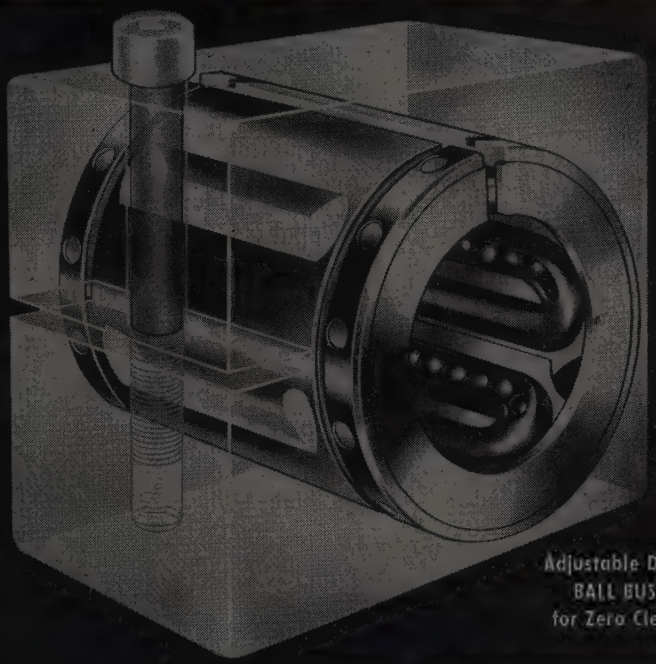
Write in No. 199 on Reader Service Card

more on page 250

NOW! *Adjustable Diameter and Open*

THOMSON

BALL BUSHINGS



Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING

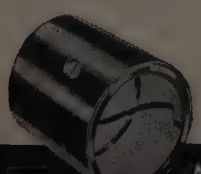
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅜" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . Hardened and Ground Steel Shafting

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COLOR TUBE
replaces monochrome type

Terrain clearance, MTI, collision warning and weather radar indicators will benefit from the 5CGP29, a two-color cathode-ray tube, says **Litton Industries, Dept. S/A, 1476 66th St., Emeryville, Calif.** The persistent phosphor screen has the same viewing area of the monochrome 5FP14, the tube for which it has been designed as a retrofit.

Monochrome display may be converted to color with the new tube and simple circuitry revisions. The tube is said to offer displays free of convergence problems, as well as excellent resolution capability. The screen consists of 80 color strips per inch. Phosphors varying in persistence and color are available, depending on application.

Write in No. 200 on Reader Service Card

SEQUENCE CONTROL
has integrated design

Safety override functions involved in missile engine operation, plus many hydraulic, pneumatic and electrical sequencing functions, may be performed by an integrated sequence control designed by **Bendix Products Div., Bendix Aviation Corp., Dept. S/A, South Bend 20, Ind.** The unit is useful during the starting, change-of-thrust, steady-state operating and shutdown regimes.

A pneumatic actuator provides power for operating the sequence valves and electric sequencer.

Write in No. 201 on Reader Service Card

THERMAL RELAY
is one-time switch

A thermal relay designed to withstand the shock and acceleration of missile operation is a direct-view switch that features a faultless hermetic seal, says **Hughes Products, Dept. S/A, International Airport Station, Los Angeles 45, Calif.** The single-action switch is a one-time operating, single-pole unit that is normally open.

A firing signal closes a contact which permanently closes the switch circuit. The 0.1-oz. device has an insulation resistance, before firing, of over 200 meg, and after firing, circuit resistance is under 0.3 ohms. About two volts are required for firing.

Write in No. 202 on Reader Service Card

COOLING ASSEMBLY
for missile tubes

High-powered electronic tubes in a missile's guidance system can be cooled with the Model E/HT-200, Type 204 assembly, which weighs ten lbs and measures 10½ x 6 x 7¾ in., says **Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden, Conn.** The coolant is ethylene glycol-water solution delivered at 0.6 gpm flow rate and 35 psi pressure at maximum temperature.

Main components include a positive pressure gear pump, reservoir with expansion facility, temperature control valve, flow switch, thermoswitch, and filter. Capacity is 1600 W, and the unit operates from a 28-V dc power supply.

Write in No. 203 on Reader Service Card

ACCELERATOR
designed for efficiency

The Model 7-34 differential transformer accelerator features temperature-compensated damping to within 0.1 per cent of critical, without the use of heaters, says **Edcliff Instruments, Dept. S/A, P. O. Box 307, Monrovia, Calif.** Any full-scale output up to 60 V may be obtained in ranges from plus or minus one to ±50 g.

Output of the unit, which is first in a series, is up to 0.5 V per volt excitation at full deflection. At zero acceleration, the deflection is under 0.5 per cent of full scale. Maximum nonlinearity is one per cent and phase shift, at zero deflection, is plus or minus five deg.

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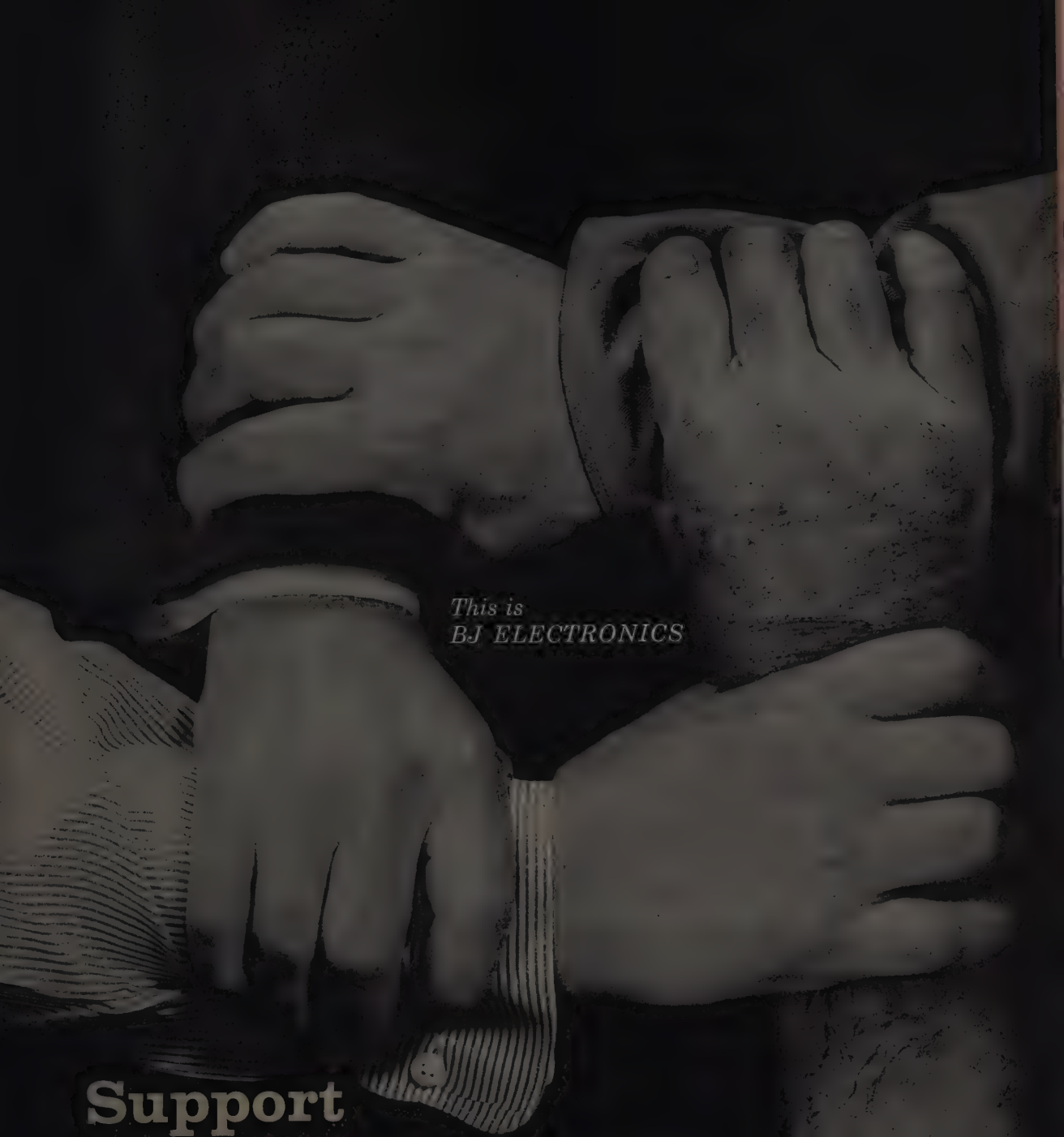

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Trim system of Sikorsky HUS-1 and HSS-1N helicopters utilizes two special Airborne rotary actuators, acting through force gradient springs, to position and hold cyclic sticks. Pilot can override springs to make a maneuver; then have stick return automatically to trimmed position.

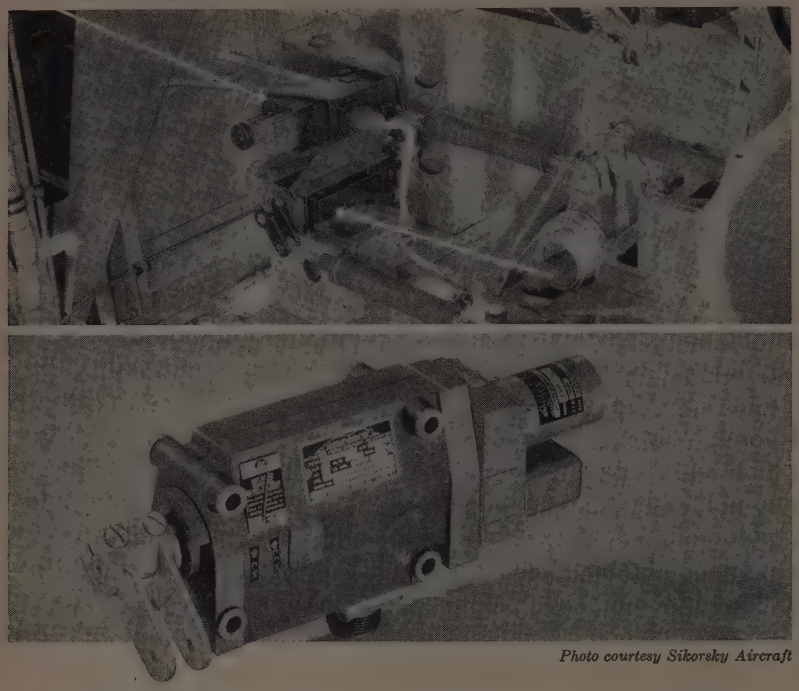

Photo courtesy Sikorsky Aircraft

Airborne special actuators provide helicopter trim control

One of the more recent applications of Airborne special design actuators is found on Sikorsky's HUS-1 and HSS-1N helicopters. Two Airborne R4610 ROTORAC actuators are used on these aircraft as the basic components of a force gradient system of trim control. The system is an ingenious one, offering the pilot several different methods of manual or power operation.

The R4610 exemplifies Airborne's capabilities in designing and developing special electromechanical actuators—both rotary and linear. And where requirements are not unique, we also offer a line of modular-type actuators, originated by Airborne to simplify design and specification problems. Write for further information.

GENERAL ENGINEERING DATA

AIRBORNE SPECIAL DESIGN
ROTORAC ACTUATOR R4610

1. 26 v d-c, split field, series wound reversible motor with magnetic brake. Capable of continuous stall.
2. Actuator speed: .62 rpm at rated torque of 20 in./lb.
3. Backlash: .006 in. maximum at 1.5 in. radius with 5 in./lb. load.
4. Ambient temperature: —65 to +212°F.
5. Design includes electric clutch, limit switches, positive mechanical stops, and radio noise filter.

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Write in No. 125 on Reader Service Card at start of Product Preview Section

RADIATION DETECTOR warns of overexposure

A detector of dangerous high-intensity radar beams that fits in a shirt pocket, gives ample warning to personnel before exposure to radar beams becomes a health hazard is now available, according to **Erickson Products Co., Dept. S/A, 1960 Carroll Aye, San Francisco 24, Calif.**

The Erickson microwave radiation detector has a neon light and earphone, both of which reflect the nearness of the individual to the radar transmitter.

Write in No. 204 on Reader Service Card

TRANSIENT ELIMINATOR protects transistors

The transient eliminators, when placed in series with power sources, absorb high-voltage transients, thereby protecting a transistor load, says **Gulton Industries Inc., Engineered Magnetics Div., Dept. S/A, 13030 Cerise Ave., Hawthorne, Calif.**

The instruments are produced in two models—Type EM 446 for airborne applications and Type EM 742 for lab or ground support equipment. Both units are rated for continuous operation at 32 V dc and 15 amp and meet Mil-E-5272. The units are protected against reversed polarity, inductive kick-back, and overvoltage, and cause only slight decreases in line voltage.

Write in No. 205 on Reader Service Card

TIMER has new escapement

This miniature time delay relay uses a new escapement designed for reliable operation under temperature, shock and vibration requirements of aircraft and missiles. Timing accuracy of this mechanism is not affected by voltage variation. Repeatability will be within ten per cent under temperature variations from —55 to +125 deg C or during vibration from five to 2000 cps, 10G maximum acceleration. Under normal test conditions repeatability will be maintained within two per cent, says **Eagle Signal Corp., Dept. S/A, Moline, Ill.**

The total mechanism is contained within a hermetically sealed tube measuring 2½ in. in length and 1¾ in. in diameter. Timing ranges are available from one to 15 seconds.

Write in No. 206 on Reader Service Card

TURNTABLE for inertial test

Model 052, a multimode turntable for evaluation of inertial navigation equipment, is designed to determine transfer functions of gyros or other inertial devices to programed sinusoids or step functions, says **J. W. Fecker, Inc., Dept. S/A, 6592 Hamilton Ave., Pittsburgh 6, Pa.**

The 26-in.-diameter platform can accept loads up to 500 pounds and has a range of turning rates of 0 to 2 rps. A microsyn drive maintains a positional accuracy of ±10 seconds of theoretical value. The photoelectric readout system provides highly accurate indication of turntable motion in the form of an electrical pulse coincident with each 6 or 10 seconds of arc.

Write in No. 207 on Reader Service Card

INKLESS RECORDER has 25 channels

Primarily designed for directly recording shaft-position data in missile flight control movement this miniature, 4-pound recorder can record missile first motion, gyro pick-off data, data from special transducers and serve as a telemetering back-up device, says **Santa Barbara Intrumentation Corp., Dept. S/A, 5481 Santa Monica Blvd., Los Angeles 29, Calif.**

A transistorized time base operating at 10 cps is standard while a 100 cps base is optional. A 27 Volt dc (governor-controlled) motor is coupled to a gear reductance train driving the tape transport system at a nominal 5 in. per second. Each of the 25 writing elements thermally transcribe the transducer functions directly on the recording medium which is either metalized Mylar, 0.0015 in. thick, or chemically treated Al-fax paper, Field strip-down of the EK-125 can be completed by unskilled personnel in less than one minute.

Write in No. 208 on Reader Service Card

more on page 256

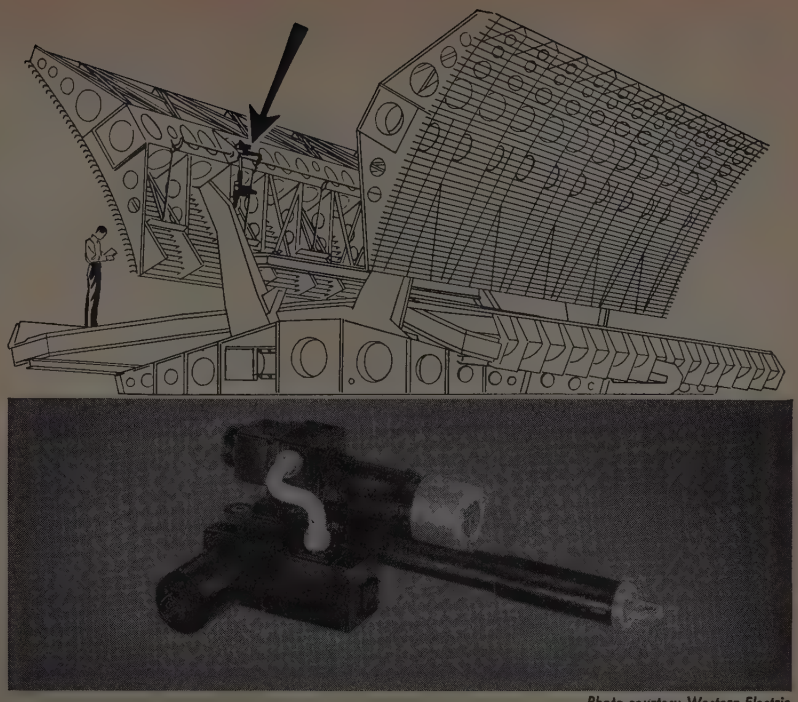

Photo courtesy Western Electric

R2552 LINEATOR exemplifies Airborne capabilities in large special actuators. Installed in pairs, units control tilt and shape of DEW Line antenna reflectors, must operate in temperatures from —65 to +130°F.

Airborne large special actuators used for DEW Line antenna control

Airborne large special actuators are being employed today in a diversity of applications, both air and ground. On the DEW Line, for example, pairs of Airborne R2552 LINEATOR actuators are used to control the tilt and shape of AN/FPS-19 antenna reflectors. Environment in this instance involves extreme temperature and humidity conditions and these call for a high order of mechanical and electrical reliability.

The R2552 typifies Airborne's capabilities in developing large special actuators—linear or rotary. And where requirements are not unique, we also offer a line of modular-type actuators, originated by Airborne to simplify design and specification. Write for further information.

GENERAL ENGINEERING DATA

Airborne Special Design
LINEATOR Actuator R2552

1. 208 v a-c, 60 cycle, 3 phase reversible induction motor with magnetic brake
2. Speed at rated load of 400 lb.: .3 in./sec.
3. Ambient temperature: –65 to +130°F. (–80°F. non-operating). Relative humidity: up to 100%
4. Design incorporates 2 limit switches and 4 intermediate position switches, plus synchro position transmitter.

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ON THE MARK . . . WITH BEARINGS FOR MISSILES

The fantastic speeds of modern missiles call for virtually instantaneous response of systems for power generation, actuation and control.

This means friction must be reduced to a minimum within stringent limits of weight and space. Torrington has brought Needle Bearings to the mark of capacity, efficiency, precision and reliability that has won them a place in operational missiles today. Torrington has developed many types for highly specialized aircraft and missile applications.

Advances in propulsion and missile control bearings are another example of Torrington's continuing research to improve bearings in design, material and performance.

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

RESEARCH FOR PROGRESS IN BEARING DESIGN AND PERFORMANCE

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ENGLISH CHANNEL CONQUERED BY AIR!

FLIGHT INAUGURATES FIRST SCHEDULED AIR SERVICE BETWEEN PARIS AND LONDON

Lucien Bossoutrot

London, Eng., Feb. 8, 1919—The first international passenger flight became aviation history today when Lucien Bossoutrot successfully landed his Farman "Goliath" aeroplane at Kenley Aerodrome after a 2½-hour flight from Paris with 13 persons aboard. Captain Bossoutrot and his co-pilot reported that the bimotor biplane performed perfectly throughout the 178-mile trip. The flight fulfilled the dream of Louis Blériot, who ten years ago made [illegible] first [illegible]

FIRST IN INTERNATIONAL AIR TRAVEL! It's as true of Air France today as it was 40 years ago when Lucien Bossoutrot made the first international passenger flight from Paris to London. Air France still follows this great tradition of French leadership in aviation. Today Air France offers the most non-stop flights between New York and Paris. This spring Air France will fly the fastest jet service in Europe and the Middle East. And next year Air France will cover the world's largest route network with one of the largest jet fleets in the world.

AIR FRANCE

WORLD'S LARGEST AIRLINE/WORLD'S FIRST INTERNATIONAL AIR SERVICE

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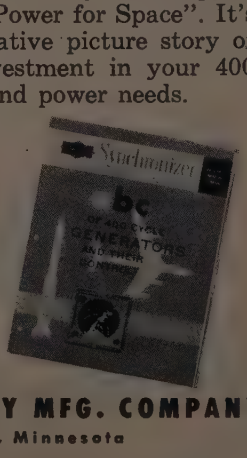
"I was afraid it would come to this."

Ground Power Problems? ...Here is the Answer!

Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.



E-M
2600-TPA-2210

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

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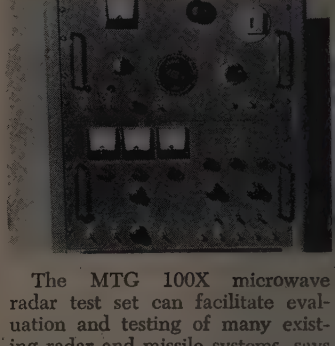
TARGET GENERATOR for radar testing



The MTG 100X microwave radar test set can facilitate evaluation and testing of many existing radar and missile systems, says **Remanco, Inc., Dept. S/A, 1630 Euclid, Santa Monica, Calif.** The X-band device provides a delayed target to a pulse radar at its microwave frequency, and the target pulse is locked to the radar frequency.

Single-dial frequency tuning is accomplished by means of a klystron with linear reflector tracking. A potentiometer geared to the tuning shaft causes the klystron to automatically track the mechanical tuning. Power output is adjustable from minus ten to −80 dbm. Together with the RP 175 moving video target simulator, the MTG forms a system capable of target velocities up to 5000 ft/sec, accelerations up to 30 g's, and ranges to 30 nautical miles. The combination system needs no additional equipment, such as spectrum analyzers, for operation, and it will permit preflight simulation of tactical in-flight conditions.

Write in No. 209 on Reader Service Card

CIRCUIT CONNECTOR for 1/16-1/8 in. boards

A printed circuit connector with exclusive bellows action contacts is announced by **Electronic Sales Div., DeJur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1, N. Y.** The universal design makes it possible for the connector to accept printed circuit boards that can vary in thickness from 1/16 to 1/8 in. Spring grip action is positive over the entire printed circuit contact area, with no distortion or stress evident.

Self-alignment of bellows contacts also allows for any residual warpage of the printed circuit board. An extra rugged molding of glass reinforced Plaskon Alkyd 446 is supplied with stainless steel mounting bushings which allow for self-alignment.

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more on page 258

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LINDE'S NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new PLASMARC Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

The quality of these pieces is uniformly high. Tolerances can be held to ±.002 in. or better. The metal loses none of its purity and superior density is achieved.

With the PLASMARC Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

The PLASMARC Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde UNION CARBIDE
TRADE MARK

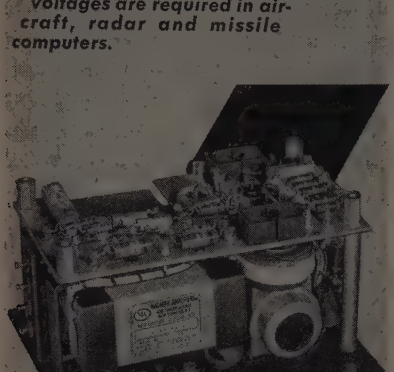
"Linde", "Union Carbide" and "Plasmarc" are trade marks of Union Carbide Corporation.

New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%
OUTPUT Nom. 115V ± 2%
400 CPS ± 0.01%
1 Ø (2- or 3-phase output available)
RATINGS: 30VA 50VA 100VA
Higher ratings available.

APPLICATION:
For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.



FEATURES:
PRECISION OUTPUT FREQUENCY
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FAST STARTING TIME
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IRDOMES from bonded sections

According to **Precision Lapping Co., Inc., Dept. S/A, 34 Clinton Ave., Valley Stream, N. Y.**, their method of producing large irdomes, makes possible bonded domes of unlimited size and accuracy. Among shapes possible are spherical sections from a slight meniscus to much more than a hemisphere, aspherics, flat and polyhedrons, made of bonded flat plates and combinations of all shapes mentioned above.

Bonded domes are available at temperatures from —238 C to +1200 C.

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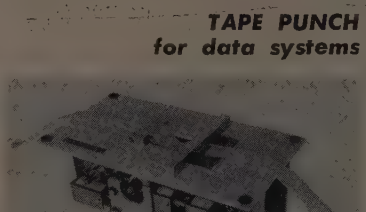
TAPE PUNCH for data systems



Designed for either console or rack mounting, this device is suitable for use with computers, and data handling and communication systems, says **Precision Specialties Inc., Dept. S/A, 1342 E. 58th St., Kansas City 10, Mo.**

The punch operates on demand, up to 27 cycles per second, with any width paper tape up to an inch in either the oil or non-oiled variety. It will punch up to 8 columns or information bits.

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COAXIAL PLUGS are lighter

Using aluminum shells, these R. F. coaxial connectors are 35% to 40% lighter than comparable standard R. F. coaxials according to **Cannon Electric Co., Dept. S/A, 3208 Humboldt St., Los Angeles 31, Calif.** Assigned the prefix AL, the plugs exceed the electrical performance of the brass-shell N and SC series. ALN and ALSC plugs have black anodic coating for maximum corrosion resistance and improved moisture sealing characteristics.

The ALN series accepts RG, Foamflex and Raytherm cable, while the ALSC accepts only RG cable. Both series have improved clamping which does not distort the cable dielectric. Two special adapters for Foamflex and Raytherm cable are also available in the new line.

Write in No. 213 on Reader Service Card

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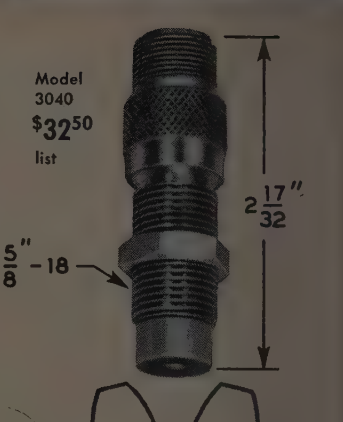
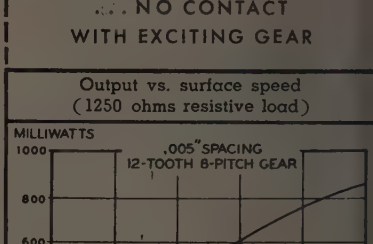
SELF-POWERED MAGNETIC PICKUP



Over-Speed Protection WITHOUT Amplification

SELF-GENERATING
. . . NO CONTACT
WITH EXCITING GEAR

Output vs. surface speed
(1250 ohms resistive load)



Physical specifications may be altered to meet your space limitations.

Also specially designed transducers for:
- metering liquid rocket fuel
- measuring speed of turbines
- generating frequency in drones.

Electro ELECTRONIC EQUIPMENT

ELECTRO PRODUCTS LABORATORIES

Sensing Elements for Control Counting Speed and Displacement Measurements

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Check Employment Inquiry Form on Page 17

J. B. WASSALL, DIRECTOR OF ENGINEERING, WITH LOCKHEED SINCE 1937

A message of importance to career-minded engineers:

"Lockheed aircraft continue to blaze new trails for manned flight. The new Electra is America's first prop-jet airliner. A Navy version of the Electra will be the country's first turbine-powered submarine hunter.

"Already, our design groups plan the supersonic jet transports of 1965. Meanwhile, new speed and altitude records set by a Lockheed F-104 Starfighter move manned flight to the fringes of outer space.

"Within and beyond lie many problems for our engineers: problems in aero and thermodynamic characteristics at supersonic speeds, in radar, in optics, in infrared, in data processing for airborne detection systems and in all phases of design. Additional long-range problems exist in military systems analysis, nuclear and space craft systems, commercial air transport studies, and industrial operations research.

"There are openings now for thoroughly qualified electronics and aero-thermodynamics and design engineers and operations research specialists.

"If you are interested in a Lockheed career in California, write us today. Address E. W. Des Lauriers, Manager Placement Staff, Dept. 107, 1708 Empire Avenue, Burburbank."

ENGINEERS: *Write Mr. Des Lauriers for your copy of a paper on "Airborne Early Warning in the Missile Age" presented by Robert A. Bailey, Chief Engineer, California Division, Lockheed Aircraft Corporation, at the 6th USAF World Wide Weapons Meet.*

Lockheed

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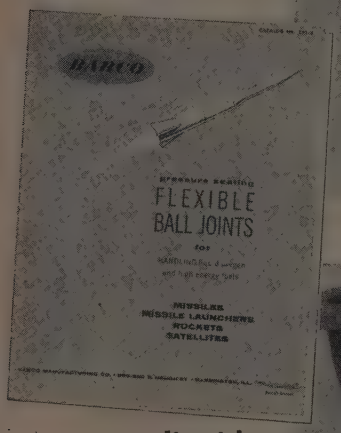
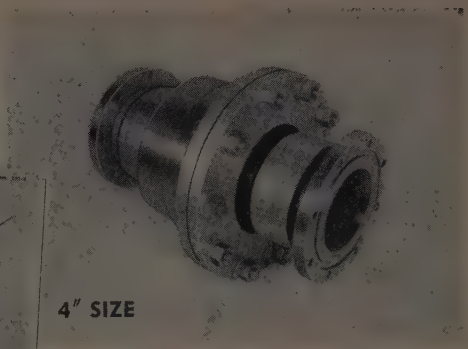
BARCO FLEXIBLE JOINTS

For Handling High Energy Fuels . . . .

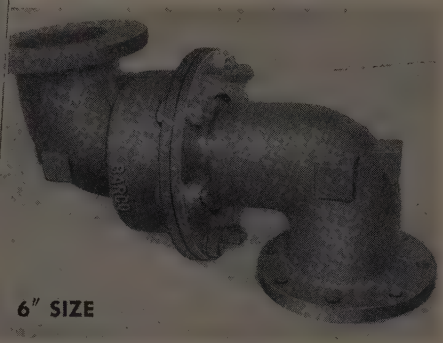




4″ SIZE

4″ special stainless steel Barco Flexible Ball Joint for handling liquid oxygen.

. . . . . liquid oxygen, white fuming and red fuming nitric acid, and JP 3, 4, and 5 fuel



6″ SIZE

180° flanged 6″ Barco Ball Joint for use in loading and unloading line handling liquid propellant.

–special designs for LOX and other Missile Fuels

Extensive design and manufacturing experience is yours to call upon at Barco for the handling of special liquid fuels in the aircraft, rocket, and missile industries:

—Flexible Ball Joints for metal loading lines handling corrosive fluids.

—Special flexible joints with leakproof seals for conveying fluids at low temperatures down to −300° F. Also high temperature designs up to +1000° F.

—Special designs resistant to nuclear energy radiation.

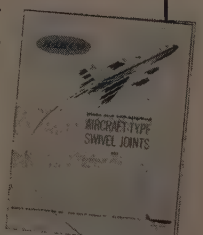
Barco joints provide flexibility *unlimited* for piping and tubing. Our engineers will be glad to work with you on special problems and assist with recommendations.

Flexible Hydraulic Lines for Missiles, Aircraft

MISSILE LAUNCHER HYDRAULIC ASSEMBLY

Barco produces high pressure self-aligning swivel joint and tubing assemblies for hydraulic pressures to 4,000 psi, and higher. Also a wide selection of standard and special swivel joints and assemblies for launching and flight gear. Sizes ¼″ to 1″.

ASK FOR NEW CATALOG 269-A.

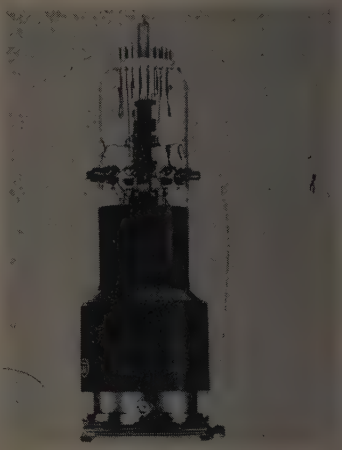


BARCO *Serving Industry Since 1908*
MANUFACTURING CO., 575D Hough St., Barrington, Ill.

AIRCRAFT DIVISION

Write in No. 132 on Reader Service Card at start of Product Preview Section

RADAR TUBE has memory



Although this information storage tube was developed primarily for defense purposes, it may show promise in applications such as the control of aircraft approaching an airport. The tube's memory would permit a tower operator to observe and record the exact course of an approaching plane, says **Westinghouse Electric Corp., Dept. S/A, Box 2278, Pittsburgh, Pa.**

The WL-7228, for use with radars, can store over 100,000 pieces of information. Three electron guns are used: one receives and writes the information on the memory unit for storage over what can be long periods; a second gun wipes out the information; and the last plays it on a fluorescent screen on demand.

Write in No. 214 on Reader Service Card

CLUTCHES for over-running use

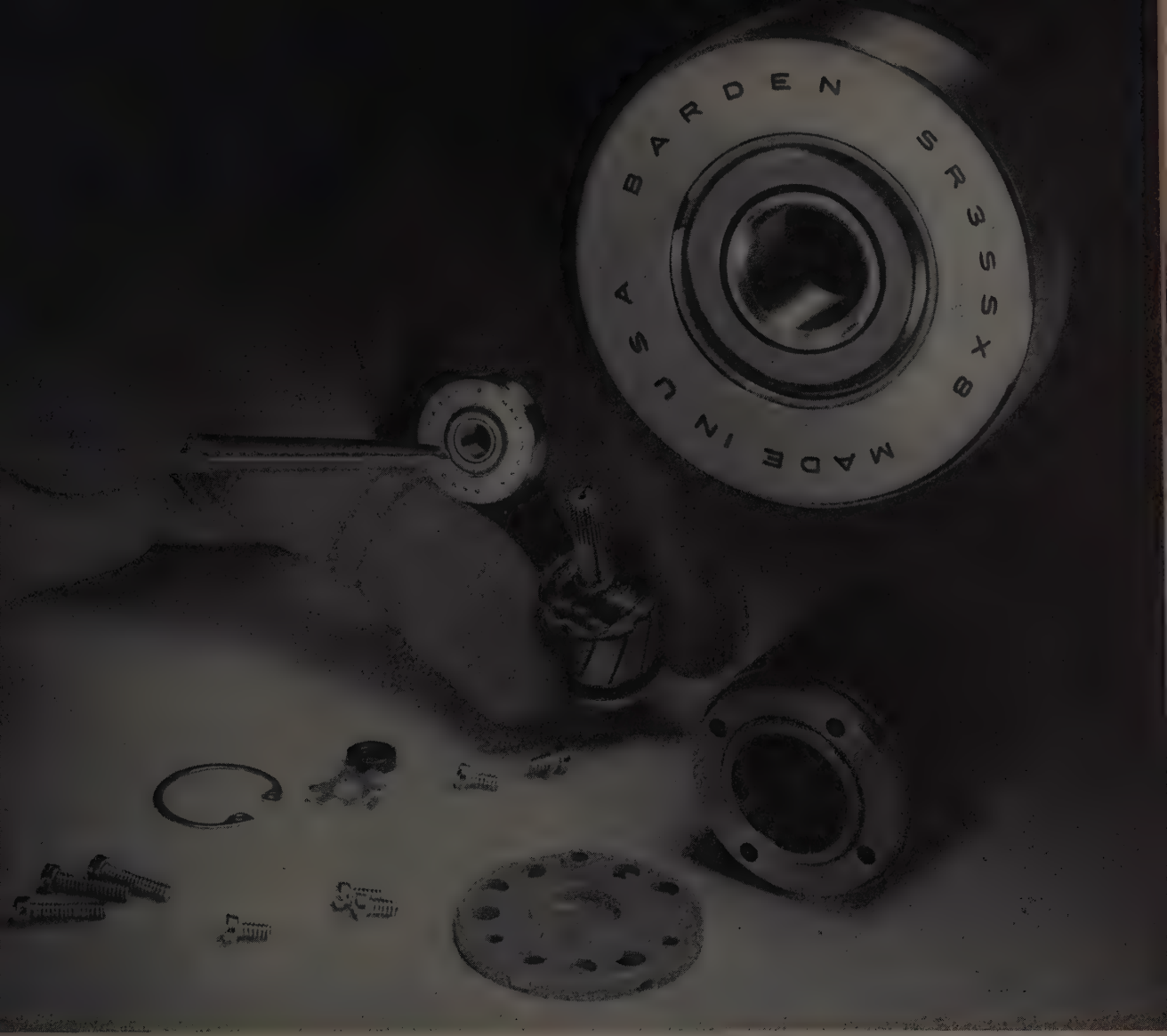
These precision spring clutches have been designed for use in all over-running, indexing, and backstopping applications, according to **Marquette Div., Curtiss-Wright Corp., Dept. S/A, 1145 Galewood Dr., Cleveland 10, O.** Long life, low maintenance and high speed operation are among the features of the self-adjusting clutch.

There are two standard types: (1) a ball bearing clutch with torque capacities ranging from 20 to 3000 lb-ft and (2) a clutch made with sleeve or plain bearing in 8-200 lb-in.-capacity units. The rated speed for the smaller sizes in both types is 3600 rpm. The largest ball bearing clutch transmits maximum torque at a rated speed of 1200 rpm; the largest sleeve bearing type transmits its maximum at 2400 rpm.

Write in No. 215 on Reader Service Card

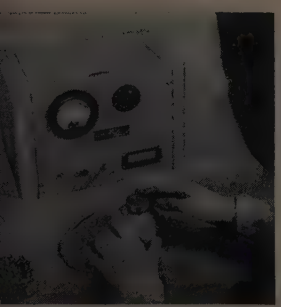
more on page 262

Write in No. 133 on Reader Service Card→



Barden Precision SR3SSX8 bearings as used in a synchro transmitter/receiver.

BARDEN *functional testing assures precision performance*



he SmoothRator, an electronic erformance tester, was developed Barden to check vibration as a easure of overall functional quality. standard quality control instru- ent at Barden, the SmoothRator also used by many leading com- onent and systems manufacturers.

Precision-built synchros require small, uniform air gaps and consistently low torque to provide accurate response to a generated signal.

Barden Precision low torque bearings assure the required air gap by close control of radial play and concentricity. The SR3SSX8 has an extra large O.D. which eliminates the need for end caps, increasing air gap accuracy and reducing synchro complexity and cost.

From research and design, through quality controlled production, functional testing and application engineering each *Barden Precision* bearing is planned for performance. *Barden Precision* means not only dimensional accuracy but performance to match the demands of the application.

Barden Precision bearings must pass rigid functional tests on the SmoothRator, the Torkintegrator and other Barden-developed or standard test devices. This functional testing is your assurance of consistent precision performance.

Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature or high speed. For less difficult applications, Barden *predictable* performance can cut your rejection rates and teardown costs.

THE BARDEN CORPORATION

72 East Franklin Street, Danbury, Connecticut

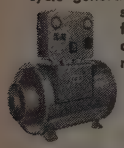
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California

ECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS

The Systems Approach to
POWER CONVERSION

The 60 to 400 cycle frequency changing motor generator set and complete controls are mounted together on the skid base. This smaller type cubical contains all necessary meters, laced and channeled circuitry, motor starter with stop and start push buttons and a Kato static REGOCITER combination voltage regulator and static exciter. Kato Magtrol static regulators are manufactured for use with brushless AC generators which must have rotating exciters.

Investigate Kato's complete line—60 and 400 cycle generators—various speeds—brushless or slip ring types—motor generators for all power converting needs—complete line of controls for all rotating electrical machinery.



Now Kato's complete line of generators is also available in brushless design.

WRITE FOR DETAILS

KATO *Engineering Company*

1424 FIRST AVE., MANKATO, MINNESOTA

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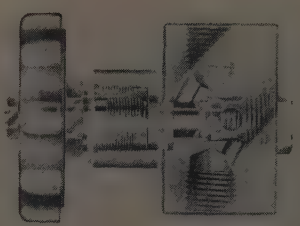
SHUTOFF VALVE is manual



This manual shutoff valve Model 949T for high pressure gas systems and missile and rocket applications features easier operation with threads out of fluid stream above the stem seal, reduced operating torque and increased depth of finger detents in handle, says **James, Pond & Clark, Inc., Dept. S/A, 2181 E. Foothill Blvd., Pasadena, Calif.**

This manual shut-off valve provides positive, leak-proof shut-off by means of a resilient O-ring yet the O-ring is withdrawn completely and automatically from the fluid stream as soon as the valve begins to open. It is rated at zero to 5,000 psi.

Write in No. 275 on Reader Service Card

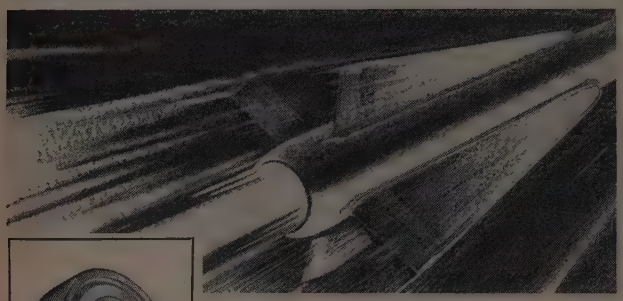
COMMUTATOR PLATING takes seconds

A new method of rhodium-plating a commutator segments has been developed that makes it unnecessary to immerse the entire armature in a corrosive plating solution, avoiding the danger of damaging the windings. Only one major piece of equipment is needed: a special rectifier with a finely graduated voltage regulator, says **Dalic Metachemical Ltd., Dept. S/A, 121 Judge Rd., Toronto 18, Canada.**

Three advantages of Dalic plating are claimed: elimination of static and interference; increased wear resistance; reduction in current required. Time to treat the commutator bars: about 45 sec; cost: about 54 cents.

Write in No. 276 on Reader Service Card

more on page 265



Minute Giants . . .

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo applications—B.M.B. have supplied miniature bearings to the American market for the past ten years.

Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

AGENTS:

David R. Grossman Co., 155 East 44th Street, New York 17, N. Y. U. S. A.

Engis Equipment Co., 431 South Dearborn Street, Chicago, Illinois, U. S. A.

Manufacturing Associates, 1416 Westwood Blvd., Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.

Sole Selling Agents:

B.M.B. Sales Ltd., High Street, Crawley, Sussex, England.

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this NO-COST TEST OFFER has CONVINCED thousands

. . . send for YOUR FREE "TEST CAN" of C-5 "hi-temp" ANTI-SEIZE THREAD COMPOUND!

For use wherever threaded connections are subjected up to 1800° F. temperatures such as boiler, manhole, face plate studs, cylinder heads, and manifold studs or flange bolts on high temp steam lines and pumps.

Try C-5 and see why leading aircraft manufacturers and thousands of industrial users have made it a part of their regular preventative maintenance program.

C-5 "HIGH-TEMP"

- ✓ Ends Seizing and Galling even up to 1800°F.
- ✓ Reduces Wrench Torque
- ✓ Ends Stud Breakage
- ✓ Permits Repeated Re-use
- ✓ Speeds Assembly and Disassembly
- ✓ Protects Stainless Steel at all Temperatures

1614-AR

ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

WRITE TODAY . . . For Your FREE Test Sample Can of C-5.

FELT PRODUCTS MFG. CO.
Dept. 52, P.O. Box 8609
Chicago 80, Ill.

Write in No. 245 on Reader Service Card

ANOTHER KAYNAR FIRST!

A brand new family of 160,000 psi locknuts

Only Kaynar uses the famous resilient, self-locking ellipse on its entire line. This exclusive Kaynar self-locking principle is covered by Pat. #2,816,591—other patents pending.

This is a family portrait of a brand new Kaynar locknut line—strength-rated at 160,000 psi. Each is related to the other by a well known Kaynar trait: unsurpassed quality. In the foreground is Kaynar's new H-14, the industry's first low height, lightweight, self-locking nut for 160,000 psi short thread bolts and screws. A product of Kaynar's leadership in research, the H-14 as well as the complete line of Kaylock 160,000 psi lightweight, self-locking nuts paves the way for better designs in every space age project.

Write today for Kaynar's new full-line brochure of 160,000 psi self-locking nuts.

KAYLOCK
All-Metal Self-Locking Nuts®

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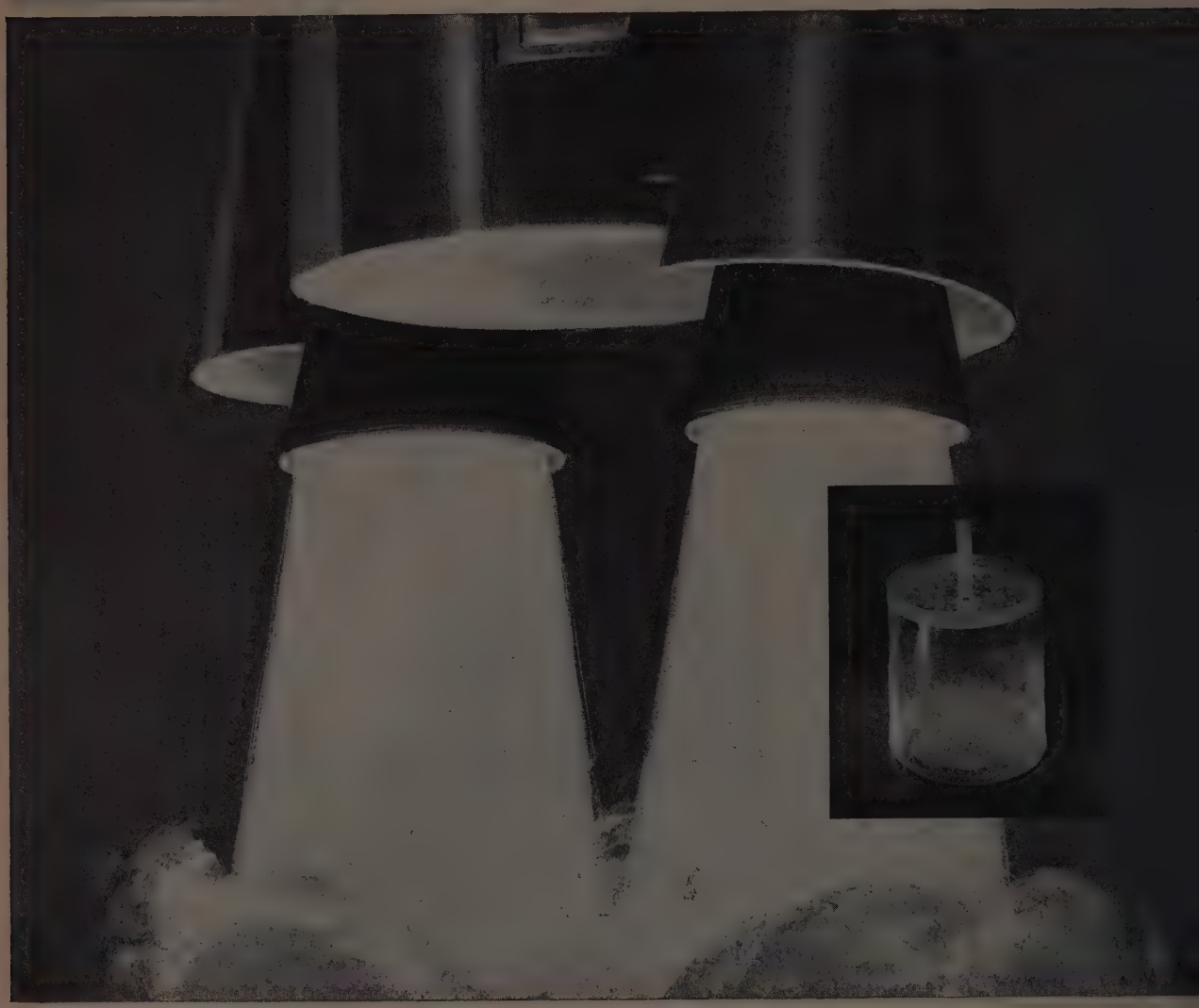
KAYNAR MFG. CO., INC.—KAYLOCK DIVISION

World's largest and oldest manufacturer of lightweight, all-metal self-locking nuts. Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54. Branch offices, warehouses & representatives in Wichita, Kansas; New York, N.Y.; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS



KEL-F® BLADDER STORES LOX or FNA

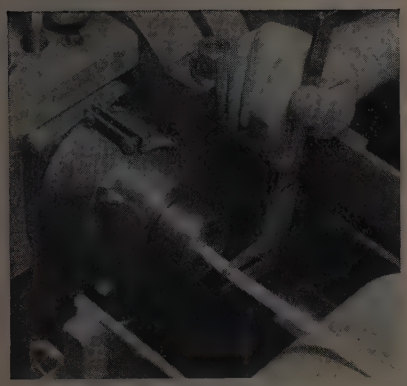
A plastic so thermally stable it can live with liquid oxygen, so chemically inert it resists both red and white fuming nitric acid! Plastic tubing of KEL-F® halofluorocarbon polymer, a 3M Chemical, is now proving itself in expellant bladders such as that shown above. Thanks to KEL-F® properties, the bladder survives contact with LOX, WFNA and RFNA. Tests by the makers of the tubing indicate that the heat-sealed bladders may safely store their contents from 3 to 5 years, perhaps longer. In addition to chemical and thermal stability, KEL-F® polymers exhibit zero moisture absorption, great dimensional stability with virtually no cold flow, excellent electrical and mechanical properties. Check the properties listed at the right, then investigate KEL-F® polymers as well as the other 3M Chemicals for the aircraft and missiles field: KEL-F® Molding Powders, Dispersions, Elastomers and Fluids, Fluorochemical inert fluids and other specialty chemicals.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



KEL-F® POLYMERS BY 3M exhibit no cold flow, can be extruded as shown above, injection or compression molded, or machined.

High dielectric strength: Short time 1/16″—530 v./mil. Very high volume resistivity: 1.2x10*18* ohm-cm. at 50% relative humidity and 25°C. Arc resistance >360 sec. Chemical and dimensional stability: After 7 days immersion in white fuming nitric acid at 90°C, weight change was only 0.3%. Wide temperature range (—320°F to +390°F) without losing useful mechanical properties. In certain applications, KEL-F® has been used at point approaching absolute zero (—460°F).

INDEFINITELY

For free literature, write on your company letterhead, specifying product interest, to 3M Chemical Division, Dept. WG-39, St. Paul 6, Minnesota.

3M CHEMICAL DIVISION, MANUFACTURERS OF: Acids • Resins • Elastomers • Plastics • Oils, Waxes and Greases • Dispersion Coatings • Functional Fluorochemicals • Inert Liquids and Surfactants.

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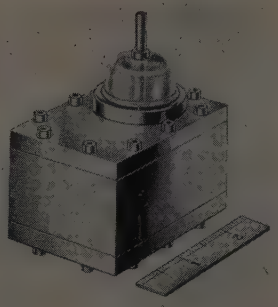
MODULATOR has low drift



The VC-713 vibrating capacitor is designed to convert dc into sinusoidal ac for easy amplification, says **Stevens-Arnold, Inc., Dept. S/A, 22 Elkins St., South Boston, Mass.** It is said to be capable of measuring currents as low as 10^{-16} amps, from a very high impedance source.

Applications for the vibrating reed-type capacitance modulator include mass spectrometry and circuits for measuring insulation resistance and dielectric leakage currents, radioactivity, and other values. Virtual freedom from drift is said to assure operation over long periods without the need for circuit recalibration. Drive frequency is 500 cps, input voltage 14 V rms, and capacity is ten mmf static. It has a conversion efficiency of about eight per cent, and contact potential is under 20 mv.

Write in No. 277 on Reader Service Card

TAPE RECORDER uses endless loop

Endless-loop magnetic tape magazines are used in Aerotape, an airborne recorder-reproducer that is designed for automatic tape theading, according to **Packard-Bell Electronics Corp., Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif.** The unit, primarily designed for military applications, accomplishes all threading when the magazine is inserted, a matter of seconds.

The magazine, several of which can be packaged in the same ½ ATR case housing the reproducer unit, uses one reel and can provide a program of 45 min duration. As the program is played, the tape is simultaneously rewound and is ready for immediate replay at the program's end. The device may also be used as a music reproducer for commercial airlines. The input power requirement is under one amp, 24 to 30 V dc.

Write in No. 278 on Reader Service Card

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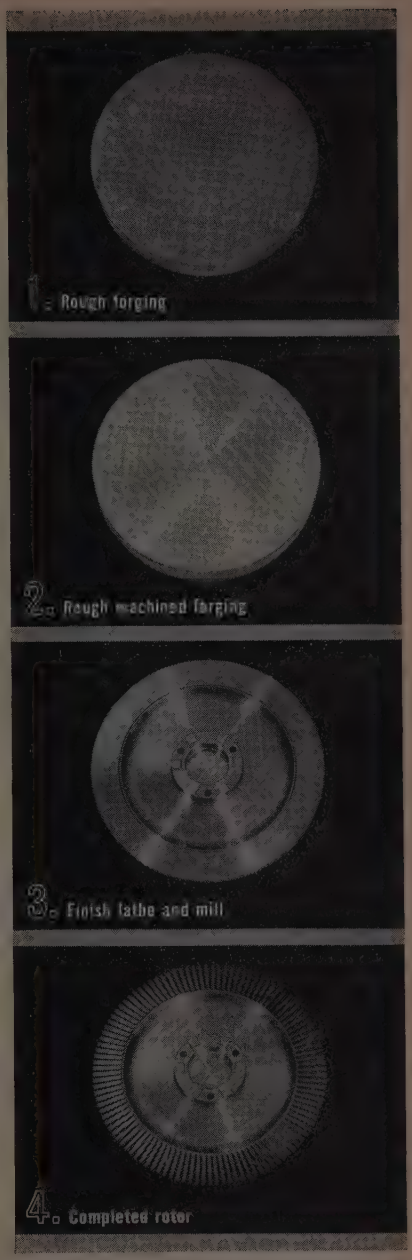

PRODUCTABILITY

New, highly-advanced techniques developed by Houston Fearless make possible substantial savings in time and cost in precision machining of extremely hard, high-temperature alloys such as Discaloy, Hastaloy, Udimet 500, René 41, Waspaloy, Inconnel X and 700. Research and development work invited. Submit drawings for help on your specific problem.

HOUSTON FEARLESS

11817 W. Olympic Blvd.
Los Angeles 64, Calif. • BR 2-4331

INDUCERS • EXDUCERS • SPECIAL WELDMENTS • ROTORS • NOZZLES • IMPELLERS • STAINLESS TANKS

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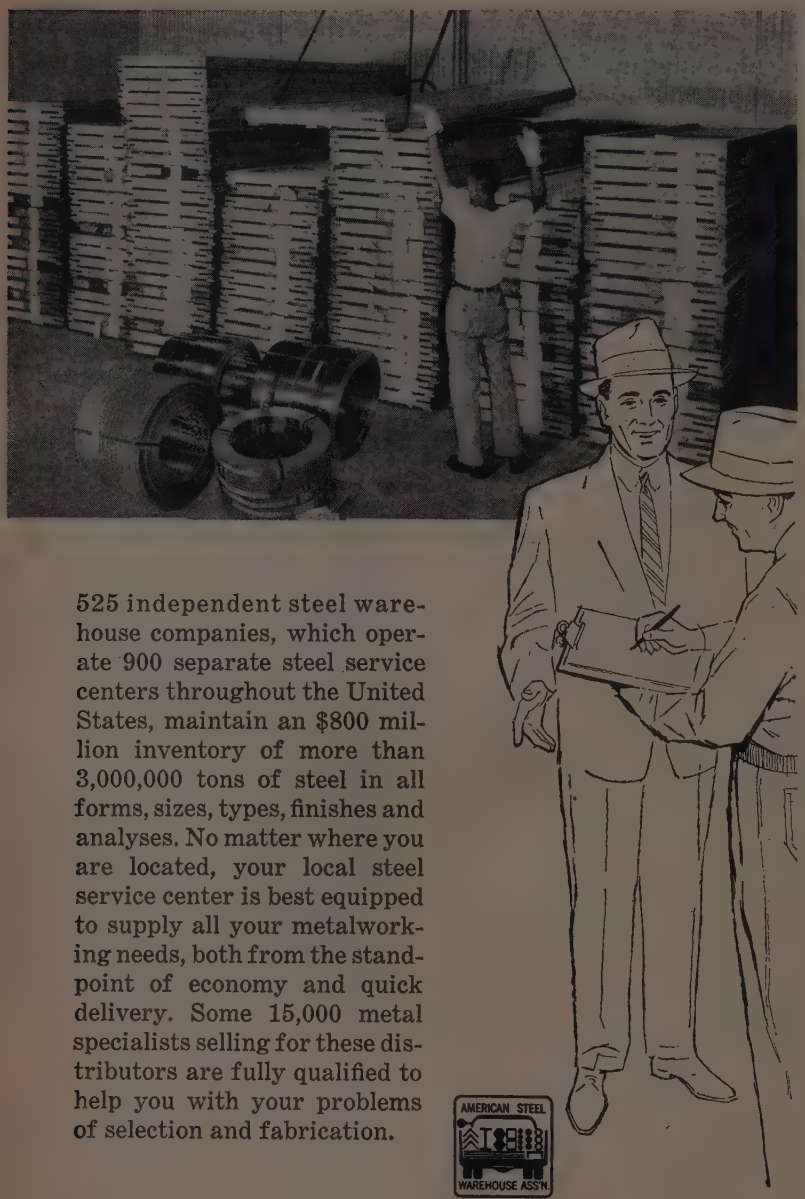
The best place to get the steel you want when you want it— is your LOCAL STEEL SERVICE CENTER



525 independent steel warehouse companies, which operate 900 separate steel service centers throughout the United States, maintain an $800 million inventory of more than 3,000,000 tons of steel in all forms, sizes, types, finishes and analyses. No matter where you are located, your local steel service center is best equipped to supply all your metalworking needs, both from the standpoint of economy and quick delivery. Some 15,000 metal specialists selling for these distributors are fully qualified to help you with your problems of selection and fabrication.

AMERICAN STEEL WAREHOUSE ASS'N

STAINLESS STEEL is stocked in 252 of these Steel Service Centers, many of which carry MICROROLD Stainless sheet and strip made by the Washington Steel Corporation.

WASHINGTON STEEL CORPORATION
3-V Woodland Avenue • Washington, Pennsylvania

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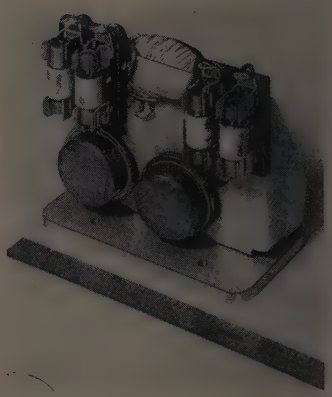
STATIC CONVERTERS are dc to dc



This complete range of transistorized static dc to dc converters are compact, lightweight, and are specifically designed to convert battery voltage dc to high voltage dc in two way radios, public address amplifiers, or wherever conventional power supplies are used, says **Universal Transistor Products Corp., Dept. S/A, 143 E. 49th St., New York 17, N.Y.**

A typical receiver supply produces 250 Vdc @ 130 ma or 290 Vdc @ 130 ma from either 12 or 13.6 Vdc input. A typical transceiver supply produces three outputs: 500 Vdc @ 165 ma, 270 Vdc @ 150 ma, and —55 Vdc @ 10 ma, from a 12 Vdc input.

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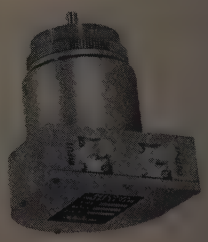
PHASE SHIFTER is accurate



Better than ±20 min accuracy from zero to 50 deg C is maintained by a phase shifter designed for precision radar applications, says **Reeves Instrument Corp., Dept. S/A, Roosevelt Field, Garden City, N.Y.** The unit's accuracy results from use of a heater winding and thermostat.

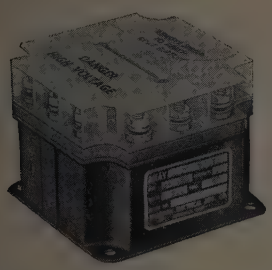
Operation is accomplished without slip rings to assure long life and noise-free operation. An output phase shift of 720 deg is obtained for each 360 deg of input shaft rotation.

Write in No. 280 on Reader Service Card

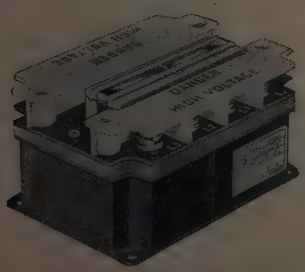
more on page 270

Write in No. 250 on Reader Service Card

B-145A—Provides inverse time delay overload protection. Signals motor contactor at first sign of trouble.



B-145B—Signals motor contactor when trouble develops.



B-145D—Supplies proportionate current to auxiliary heater in motor thermostat so as to overcome thermal lag. Signals motor contactor when trouble is detected.

Hartman

MOTOR PROTECTOR RELAYS

fault-finders, all!

They monitor motor current for short circuits to ground and for overcurrents. Inverse time delay allows for starting inrush and transients, but quickly senses locked rotor, overloads, winding to winding, or turn to turn faults. All three models shown will detect ground faults instantly. Static elements are potted to withstand high frequency vibration and environmental conditions.

With the protection provided by these relays...

- A fault is detected and cleared instantly.
- Fault damage, if any, limited so motor can be easily repaired.
- Available in any HP rating.

For details, more information, send to Control Headquarters—both AC and DC

Hartman
ELECTRICAL MFG. COMPANY
175 N. DIAMOND ST., MANSFIELD 1, OHIO

KEARFOTT TACHOMETERS

...compact, light-weight, high-performance

Kearfott offers one of the broadest lines of precision tachometers in the industry. Light, compact and resistant to temperature, vibration and shock, they are available for a wide variety of applications.

Size 11 (R860)

Integrating Tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration, rate computation, etc. In addition to reducing the in-phase null level toward zero, errors due to temperature effects are minimized over a wide ambient range. Linearity, in some cases as low as .01%, is usually better than ±.1%, while phase shift is 0±1°. For extreme accuracy, models with low temperature coefficient drag cups are also available.

Rate Generators feature high output-to-null ratios and are designed for application as rate servos and to provide damping in very high gain systems. These Kearfott units offer high linearity, high output and low inertia and are often integrally coupled to a low inertia motor; in this design the in-phase null is virtually reduced to zero. Quadrature null is as low as .25% of the 1000 rpm outputs while harmonics seldom exceed .1% of the output at 1000 rpm.

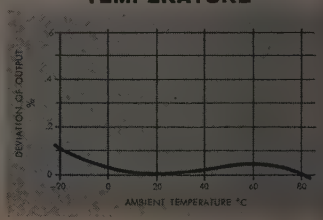
Damping Tachometers have relatively low output-to-null ratios and are designed primarily for damping purposes. They feature extremely low inertia and power consumption, linearity which is normally within ±.5%, and phase shift within 10° of reference. Kearfott damping tachometers are usually integrally coupled to a low inertia motor.

INTEGRATOR TACHOMETERS

(Typical Characteristics)

	Size 11 (R860)	Size 15 (T816)	Size 18 (V892)
Excitation Voltage (400 cps)	115	115	115
Volts at 0 rpm (RMS)	.020	.020	.010
Volts at 1000 rpm (RMS)	2.75	2.7	2.00
Phase shift at 3600 rpm	0°	0°	0°
Linearity at 0-3600 rpm	.07	.05	.07
Operating Temperature Range	−54° + 125°	−54° + 125°	−54° + 125°

TEMPERATURE

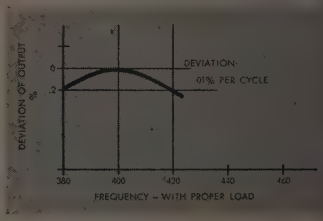


RATE TACHOMETERS | DAMPING TACHOMETERS

(Typical Characteristics)

	Size 15 (R800)	Size 18 (V806)	Size 8 (M824)	Size 10 (P822)	Size 11 (R809)
Excitation Voltage (400 cps)	115	115	26	115	115
Volts at 0 rpm (RMS)	.013	.026	.015	.019	.019
Volts at 1000 rpm (RMS)	3.1	3.0	.234	.450	.5
Phase shift at 3600 rpm	5°	4.5°	10°	5°	5°
Linearity at 0-3600 rpm	.25	.25	.3	.3	.3
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°

FREQUENCY

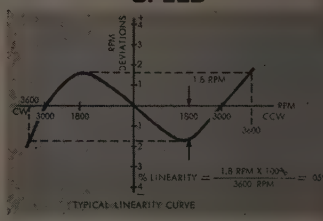


INTEGRAL SERVO MOTOR DATA

(Typical Characteristics)

	Size 8	Size 10	Size 11	Size 15	Size 18
No Load Speed (RPM)	5400	6600	5500	8000	8000
Stall Torque (oz. in.)	.3	.35	.55	.45	1.30
Excitation Voltage (400 cps)	18-40	26-40/20	115-40/20	115-40/20	115-115/57.5
Rotor Moment of Inertia (Gm.CM²)	1.3	.76	7.7	7.0	35
Operating Temperature Range	−54° + 100°	−54° + 125°	−54° + 125°	−54° + 125°	−54° + 125°
Unit Weight (incl. tachometer)—oz.	3.1	4.6	9.0	14.0	30

SPEED



Write for technical data

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
Sales and Engineering Offices: 1378 Main Ave., Clifton, N. J.
Midwest Office: 23 W. Calendar Ave., La Grange, Ill.
South Central Office: 6211 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

Kearfott | A GENERAL PRECISION COMPANY

Write in No. 251 on Reader Service Card

Write in No. 252 on Reader Service Card→

GPL research

Nuclear Gyros

GPL research is now studying for the U. S. Air Force, the feasibility of harnessing the most efficient gyro known to science—the nucleus of the atom. Development of such a gyro—tremendously accurate, perfectly balanced, friction and maintenance free—will revolutionize space reference, navigation and guidance techniques.

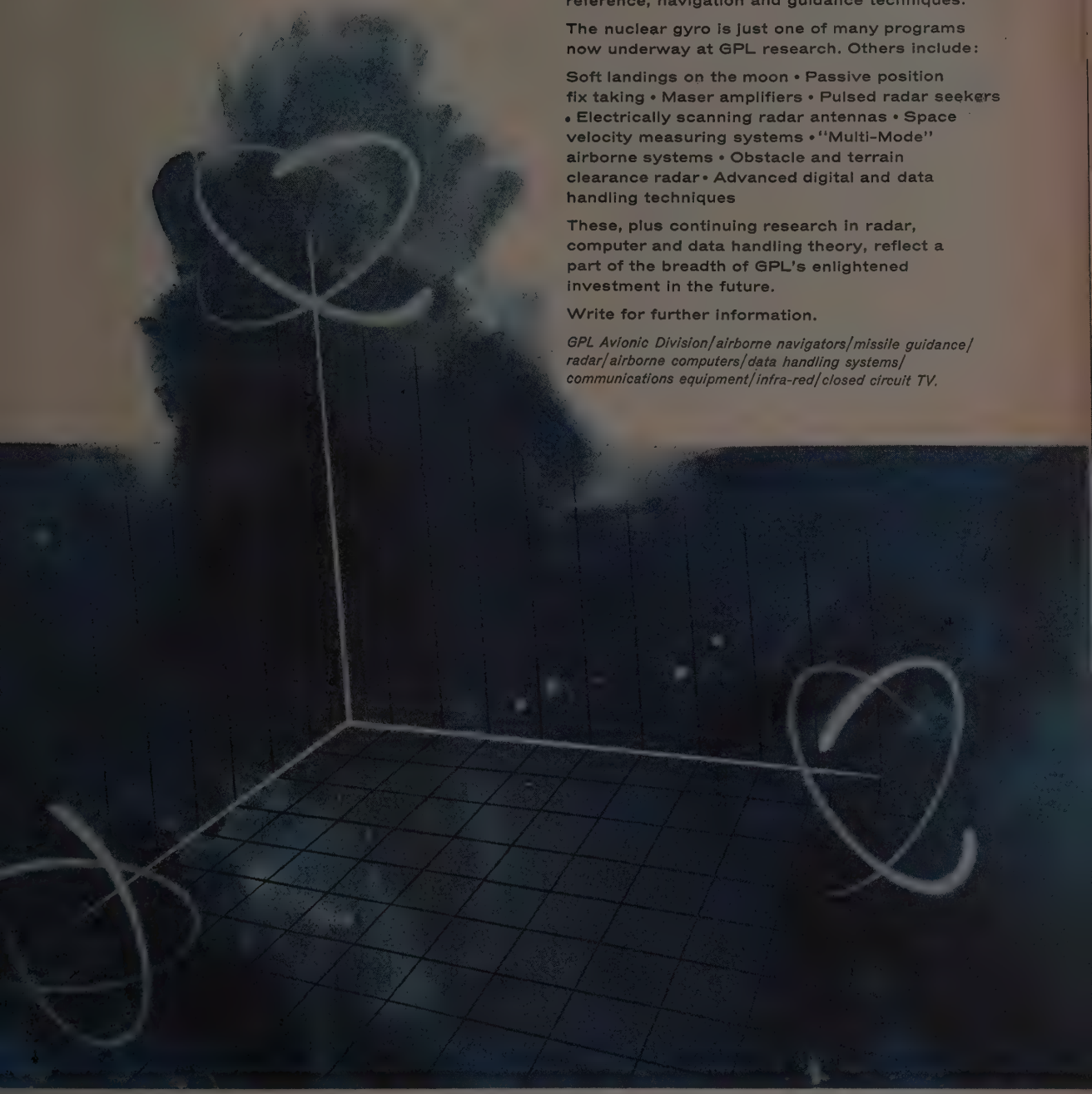
The nuclear gyro is just one of many programs now underway at GPL research. Others include:

Soft landings on the moon • Passive position fix taking • Maser amplifiers • Pulsed radar seekers • Electrically scanning radar antennas • Space velocity measuring systems • "Multi-Mode" airborne systems • Obstacle and terrain clearance radar • Advanced digital and data handling techniques

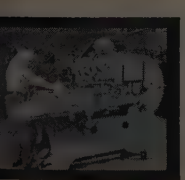
These, plus continuing research in radar, computer and data handling theory, reflect a part of the breadth of GPL's enlightened investment in the future.

Write for further information.

GPL Avionic Division/airborne navigators/missile guidance/ radar/airborne computers/data handling systems/ communications equipment/infra-red/closed circuit TV.



ENGINEERS — GPL achievements have opened up some unusual research and development opportunities. Send resume to Personnel Director.



MANUFACTURING

ENVIRONMENTAL TESTING

CUSTOMER SERVICE

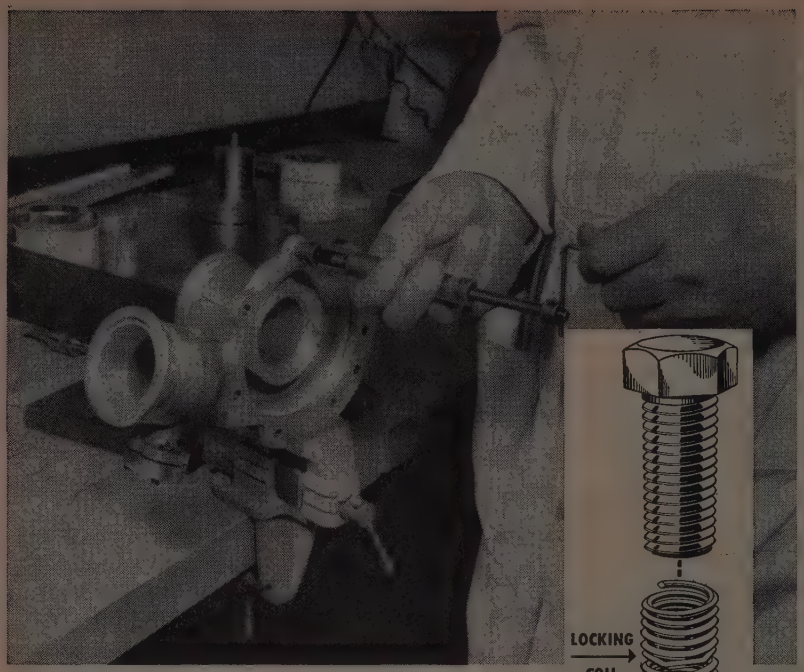
RESEARCH / ENGINEERING / FLIGHT TESTING

GPL

A GENERAL PRECISION COMPANY

GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y.

A Subsidiary of General Precision Equipment Corporation



Heli-Coil® stainless steel Screw-LOCK Insert is easily wound into tapped hole in aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation

Saves 40% in weight • 30% in assembly time ...with *HELI-COIL*® SCREW-LOCK INSERTS*

Use of aluminum makes Carrier installation lighter in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the *Heli-Coil* stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight reduced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel *Heli-Coil* Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight. *Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 103 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-LOCK Inserts

NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 1566

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.
Write in No. 253 on Reader Service Card at start of Product Preview Section

BEAM-SWITCHING TUBES in complete line

A full line of magnetron beam-switching tubes is available in production quantities from the **Electronic Tube Div., Burroughs Corp., Dept. S/A, Plainfield, N.J.** The tubes may perform the functions of 20 or more tubes or transistors. This high vacuum electronic distributor has an estimated life span of 50,000 hours. Characteristics include shock, 375G; temperature range of —60 to +150 deg C; vibration, 20G; and a speed up to 20 mc.

Type 6700 operates between 75 to 300V with a switching rate above two mc and type 6701 from 12 to 25V with a switching rate above one mc. Type Mo-10R is the same as 6700 except that it has ten internally mounted space load vacuum resistors to permit operation at higher frequencies and with a reduced number of external stem leads.

Write in No. 281 on Reader Service Card

CIRCUITS in plug-in line

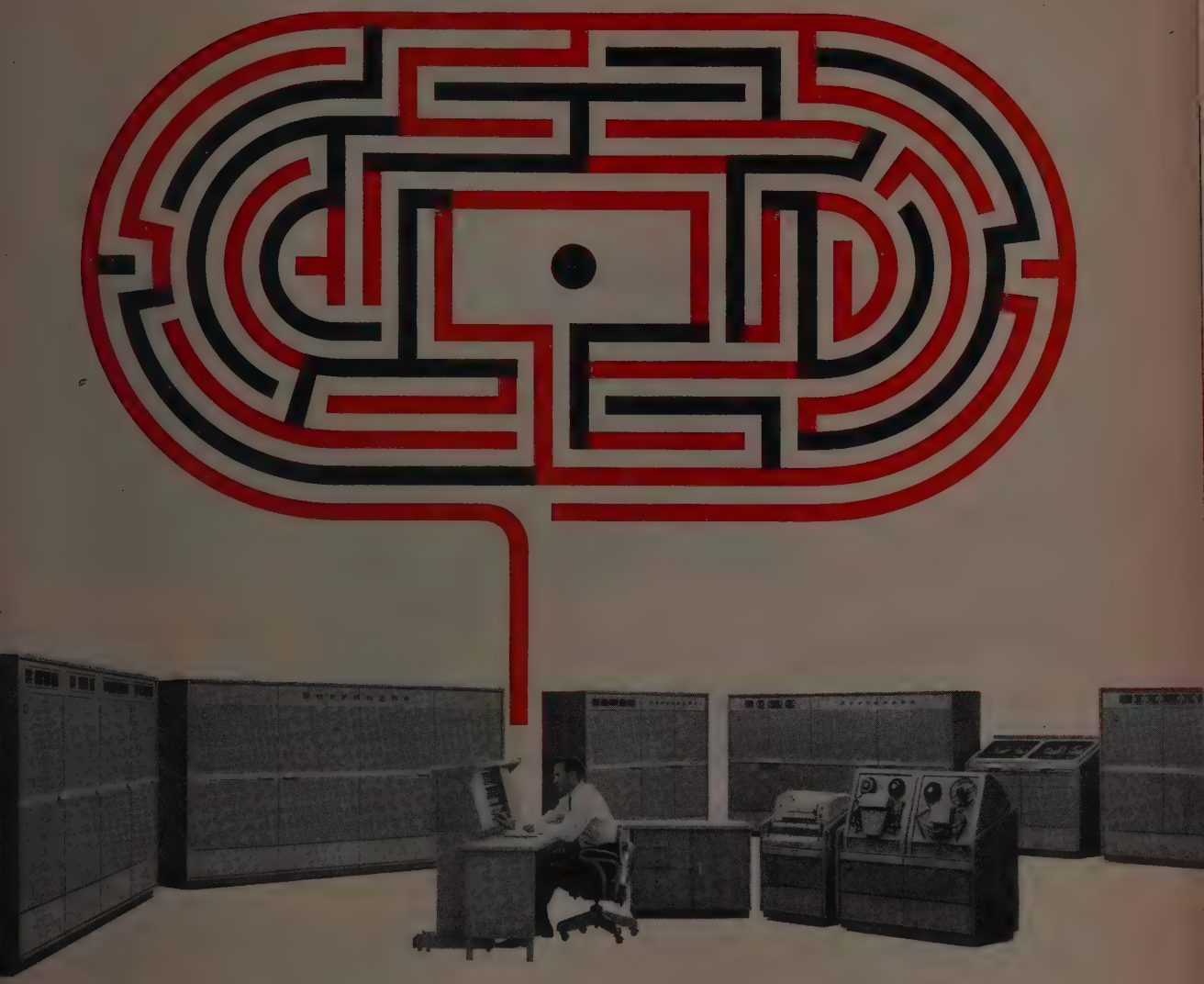
A completely new line of Plug-In Electronic circuits are being made in four standard series, says **Dayton Electronic Products Co., Dept. S/A, 320 Vermont Ave., Dayton 4, Ohio.** The NBS series comprises circuits recommended for use in Navy electronic equipment by the National Bureau of Standards. The Instrument series includes gate circuits, multivibrators, dc amplifiers and other instrument circuits with high degree of precision. The Transistor series features miniaturized plug-in modules in a variety of circuit applications. The General Purpose series includes a wide variety of voltage and power amplifiers plus control, regulating, and computing circuits.

All new plug-in units are designed on a basic size module to simplify physical design problems.

Write in No. 282 on Reader Service Card

more on page 274

Write in No. 254 on Reader Service Card→



solving today's problems today: Burroughs 220 Computer

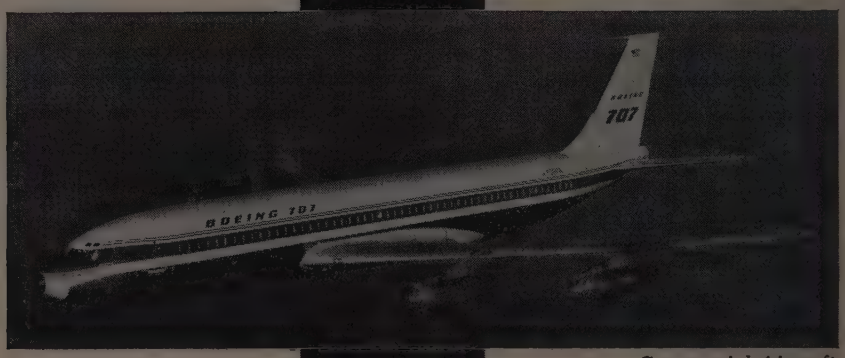
In scientific computation and business data processing, the new Burroughs 220 is delivering tangible results today. Linking a powerful digital computer to equally powerful input-output subsystems, the 220 offers balanced performance at the lowest application cost. Its expandable core memory, built-in floating decimal arithmetic, vast Datafile magnetic tape capacity and the multiple-card processing ability of Cardatron make this the most powerful system available in the medium price field. The 220 is just one part of a complete line of advanced Burroughs electronic data processing equipment... now in production... now at work in hundreds of installations... supported by an outstanding team of computer specialists. Write today for 220 brochure, ElectroData Division, Pasadena, California.

Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"

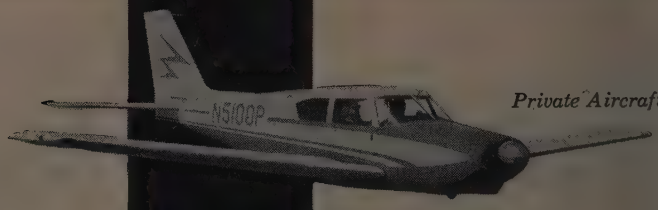
When aluminum

Executive Aircraft



Commercial Aircraft

is part of your product



Private Aircraft

. . . check with ANACONDA ALUMINUM!

If your product demands aluminum to exact specifications—and you're not getting it—call on Anaconda! Custom production, combining precision control of the most modern equipment available with the craftsmanship of aluminum experts, assures you that Anaconda Aluminum always matches your product specifications precisely. And the flexibility of our modern plant facilities gives your orders fast action, prompt shipment.

Talk over your requirements for pig and ingot, coiled and flat sheet, extruded shapes, structurals, rod, bar and tubular products now with your local Anaconda Aluminum representative . . . or write our General Offices, Dept. SA-3, Louisville 1, Kentucky.

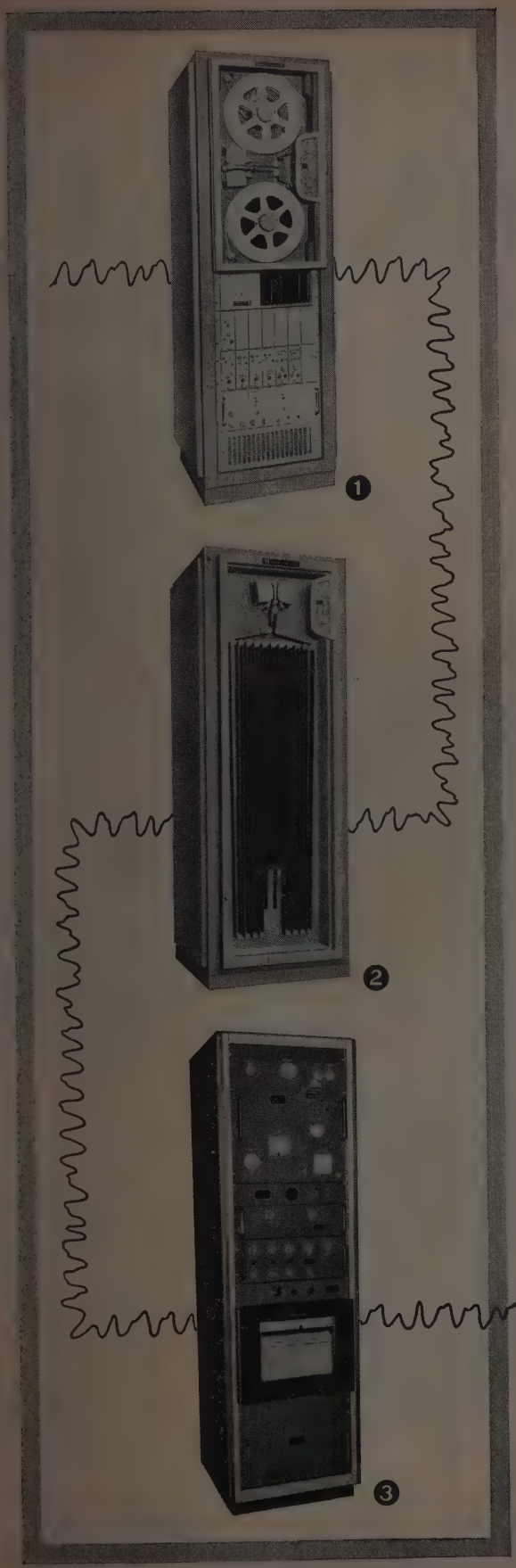
ANACONDA ALUMINUM®

Remember...

Every industry has one member who specializes in customer satisfaction

ANACONDA ALUMINUM COMPANY • GENERAL OFFICES, LOUISVILLE, KENTUCKY

Write in No. 255 on Reader Service Card at start of Product Preview Section



Procedure:

wave analyses to meet space-age requirements

Still using tedious, time-consuming methods for analyses of vibration, noise and other complex wave phenomena? Then see how this automated method saves time, increases accuracy, speeds test results.

❶ Record data on a Honeywell Series 3170 magnetic tape system. Data may be, for examples, from wind tunnel, static test, missile firing, electronic circuit, seismograph, medical probe, or any other complex signal source. The system may be airborne, fixed or mobile . . . all capture every component from d-c to over 100,000 cycles per second.

❷ Playback, edit and transcribe selected part of data to magnetic tape loop. Adjust playback speeds from 0.3 to 60 inches per second, to give time base expansion or contraction as needed. Honeywell loop transport features same high precision, low flutter performance as Series 3170 record-reproduce systems.

❸ Feed signal from loop to Honeywell Automatic Wave Analyzer. Select amplitude vs. frequency, power vs. frequency, linear or squared readings from the *ElectroniK* recorder. Get permanent, graduated chart record, with amplitude accuracy within ±0.2 percent full scale, in minutes.

The most important step in the procedure is to standardize on the complete Honeywell system. Then you get uniform high quality, guaranteed accuracy and one-maker responsibility. For help in selecting automatic wave analyzer systems, call on your nearby Honeywell field engineer . . . he's as close as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., 10721 Hanna St., Beltsville, Md.

Honeywell

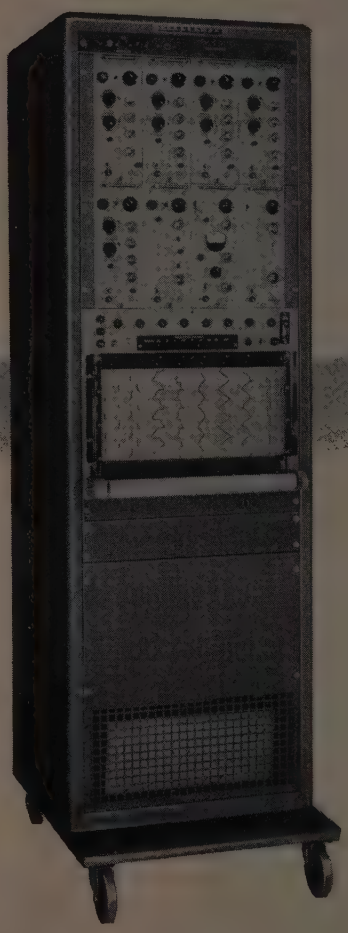
First in Control

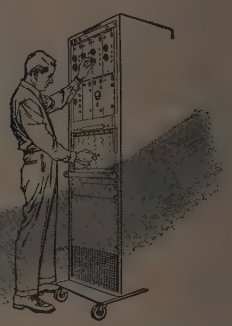
Write in No. 273 on Reader Service Card at start of Product Preview Section

- **Flat frequency response** from 0 to 100 cps
- **Galvanometer** natural frequency 55 cps
- **Hysteresis less than ± 0.1 div.**
- **True velocity damping** for galvanometer at all times — limiting ahead of output stage
- **Current feedback power amplifiers** eliminate effect of galvanometer resistance changes due to temperature
- **Linearity 0.2 div.** over entire 50 div. chart width
- **Gain stability** better than 1%
- **Base line drift less than 0.2 div.** over 20°C. changes
- **Automatic stylus heat control**
- **Inkless recording** in true rectangular coordinates

PERFORMANCE

is the best proof of SANBORN "350" System Quality





Only the Sanborn "350" oscillographic recording system offers *both* superior performance *and* operating versatility. You can interchange the plug-in preamplifiers — or use them separately with their own power supplies to drive a scope, meter, or optical oscillograph. The compact recorder (17½ inches tall), complete with transistorized power amplifiers and power supply, may also be used separately (sensitivity 0.1 volt/chart division). That's real versatility!

Recorder features include built-in paper footage indicator, paper take-up, 8" of visible record, simple paper loading from the front. Nine electrically controlled chart speeds are selected by pushbuttons, and have provision for remote control. Connections are also provided for output monitoring.

All these features — plus well-known Sanborn reliability — are yours in the Sanborn "350" system. Ask your local Sanborn Industrial Sales-Engineering Representative for complete facts — or write the Industrial Division in Waltham.

8-CHANNEL SANBORN "350"
Direct Writing Oscillographic Recording System . . .
also available with 6 channels

At the I.R.E. Show — Booths 3601-3605

SANBORN COMPANY
175 Wyman Street, Waltham 54, Mass.

Write in No. 385 on Reader Service Card at start of Product Preview Section

missile circuitry must be dependable and economical, too!

Formica® XXXP-36
. . . now better than ever!

- 12# average bond strength
- 500°F solder heat resistance
- 1 million megohms IR
- Cold punch 1/16"
- Dimensional stability
- Low moisture absorption

Circuitry in the Bomarc—and many other missiles, too—is made of Formica XXXP-36. It's recognized everywhere as one of the best paper base copper clad laminates ever made, and yet it's definitely not a premium price sheet. Therefore, the valuable properties shown at left (normally found only in premium sheets) cost circuit manufacturers nothing extra.

For complete information on XXXP-36 and the other outstanding grades in the Formica copper clad line, get your copy of the new Copper Clad Technical Data Book, form 830. Phone your district Formica representative, or write Formica Corporation, a subsidiary of American Cyanamid, 4538 Spring Grove Ave., Cincinnati 32, Ohio.

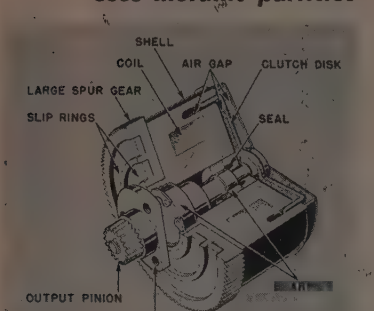
IRE SHOW . . . be sure to visit us in booth 4404-6!

FORMICA

a product of CYANAMID

Write in No. 258 on Reader Service Card at start of Product Preview Section

CLUTCH
uses metallic particles



This magnetic-particle clutch completed more than 54,000,000 operations during recent testing, with no deterioration in performance. During the same test, the unit completed over 1,000 hours of continuous testing. Capable of frequency responses of 20 cps with less than three db attenuation, the clutches were originally developed for use in fast response, lightweight servo actuators, says **Lear Inc., Dept. S/A, P.O. Box 688, Grand Rapids, Mich.**

The design features a patented metallic-particle mixture which fills the air gap between the clutch body and the low-inertia disk. The clutch body rotates continuously.

Write in No. 285 on Reader Service Card

EPOXY RESIN
shows good adhesion

TC-459, a two-part epoxy resin, has superior mechanical and dielectric strength and excellent adhesion to rubber, neoprene and Polyvinylchloride, says **Electronic Production Development, Inc., Dept. S/A, 138 Nevada St., El Segundo, Calif.**

The compound has a dielectric constant of 3.2. Dielectric strength is 1500 V per mil. Insulation resistance is 10^{12}-10^{14} ohms. The compound has a fast cure cycle: 30 minutes at 200 deg F, 60 minutes at 170 deg F, and overnight at room temperature.

Write in No. 286 on Reader Service Card

RELAY
is micro-miniature

This micro-miniature relay, the Husky Style 6, is a relay of the crystal can type, available in a variety of terminations and styles, says **Price Electric Corp., Dept. S/A, Frederick, Maryland.**

The lightweight unit is said to offer the capacity and reliability of a much larger relay in a miniaturized enclosure weighing only 0.5 per cent. It is designed for continuous use in ambients of —65 to 125 deg C with a minimum life expectancy of 100,000 operations. The style 6 meets the applicable portions of MIL-R-25018 and MIL-B-5757C.

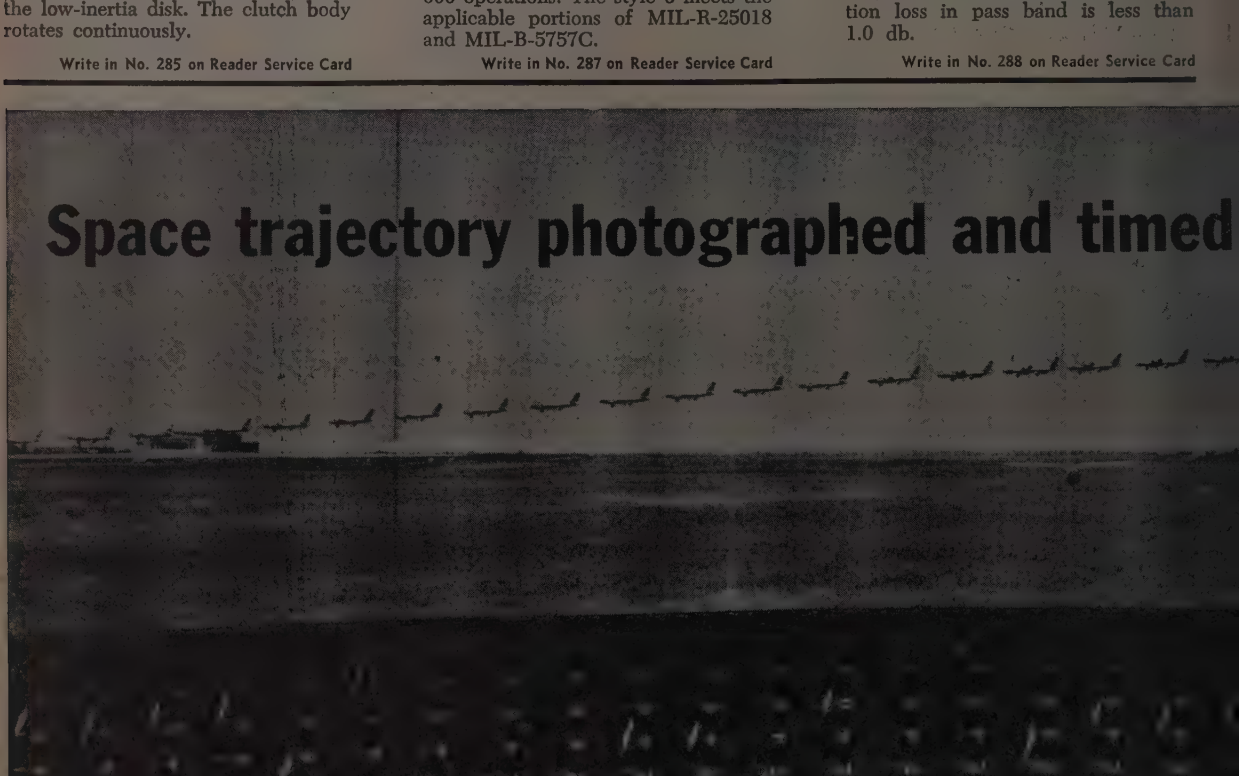
Write in No. 287 on Reader Service Card

FILTER
with ganged tuning

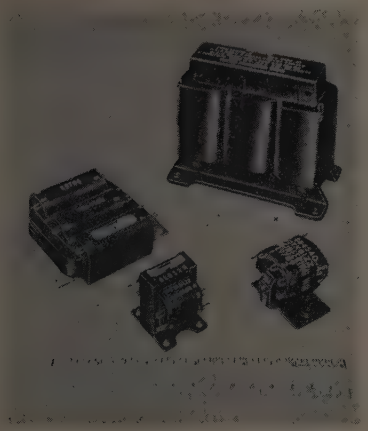
This multi-element, single-knob preselector filter offers the high selectivity and precise gang tuning of all four sections needed in interference reduction and spectrum control in radar systems, says **Airtron, Inc., Dept. S/A, 1096 W. Elizabeth Ave., Linden, N.J.** The maximally flat design uses quarter-wave aperture couplings between Invar cavities that are operated in the low-loss circular TE_{011} mode, with non-contacting choke-type plungers as tuning elements.

When continuously tuned over a range of 9300-9500 mc/s, the insertion loss in pass band is less than 1.0 db.

Write in No. 288 on Reader Service Card



TRANSFORMERS for high temperatures



Reduced size combined with extreme reliability at ambient temperatures from 125 to 175 deg C are obtained with improved Epseal encapsulated power transformers for missile and aircraft applications by **Electro Engineering Works, Inc., Dept. S/A, 401 Preda St., San Leandro, Calif.** The new units employ a coil construction and special high temperature insulations permitting greater miniaturization and reduce temperature rise as much as 50 per cent under conventional constructions.

Features of the new construction include an exclusive moisture barrier that prevents moisture penetration without a heat-retaining outer encapsulation; increased efficiency and good voltage regulation, and special encapsulation techniques.

Write in No. 289 on Reader Service Card

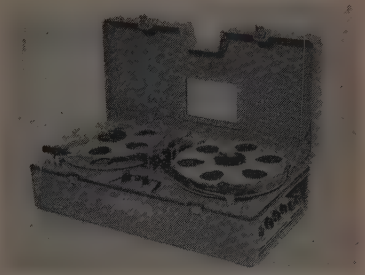
OSCILLOSCOPE records pressure changes

For the specific purpose of recording closed bomb phenomena with minimum maintenance and service, **Armament Division, Universal Match Corp., Dept. S/A, St. Louis 21, Mo.,** have developed an oscilloscope used in tests on solid propellant powders. The design is based on the simplest circuitry needed to linearly record the changes in pressure occurring in the closed bomb as noted by the potential developed by a piezoelectric transducer used as a sensing mechanism.

By means of a firing circuit contained in the oscilloscope, the propellant powder is ignited inside the bomb, where it burns under conditions simulating to some extent those experienced in a gun barrel. A plot of the rate at which the pressure changes inside the bomb is recorded against the total pressure within the bomb on a calibration grid.

Write in No. 290 on Reader Service Card

TAPE RECORDER for airborne use



Type 5-702 Magnetic Tape Recorder meets or exceeds IRIG and NATC specifications and operates at altitudes up to 100,000 ft and in temperatures from 155 to ±100 deg C, says **Consolidated Electrodynamics Corp., Dept. S/A, 300 No. Sierra Madre Villa, Pasadena, Calif.**

Among the recorder's advanced features are electrical selection of the six tape speeds, (1⅞ to 60 ips), elimination of belts and pulleys, and grouping of all controls on top of instrument. Furnished with reproduce as well as record magnetic head stacks, the unit permits downstream monitoring of all tape tracks simultaneously and practically coincident with the recording of data. It is available in seven or 14-track models, using ½ of one inch tape respectively.

Write in No. 291 on Reader Service Card

on a single record!

Fairchild Flight Analyzer produces a photograph with 56 images, appearing at equally spaced intervals along the trajectory

The Fairchild Flight Analyzer lowers data reduction costs while providing a high order of accuracy of basic data. It actually eliminates three of the major disadvantages inherent in many instruments currently in use for space movement recording: 1. their inability to track at high azimuth rates; 2. the high cost of reducing data; 3. time delays pending outcome of previous runs.

What the Analyzer does

The Fairchild Flight Analyzer produces a record which is a true, undistorted graph, self-plotted by the object at a constant scale. Simultaneously, a timing record is superimposed on the base of the picture strip by an auxiliary lens (see photo). The engineer gets an immediate "quick look" at data on attitude, position and relative time, all on a single record.

Records actual angular data

Unlike a cine-theodolite, which records a fore-shortened, vari-sized image, the Flight Analyzer records a true space position and attitude. Thus, all angular data is actual and requires no correction. Data gives smooth curves permitting determination of velocity to within 1 mph or less, and accelerations of 0.5 ft/sec/sec.

For complete 24-page technical manual on the Fairchild Flight Analyzer, write to Industrial Products Division, Dept. 15, Fairchild Camera and Instrument Corporation, 5 Aerial Way, Syosset, L. I., N. Y.

Represented in the 11 Western States by Gordon Enterprises, 5362 N. Cahuenga Blvd., No. Hollywood, Calif.

INDUSTRIAL PRODUCTS DIVISION

FAIRCHILD

CAMERA AND INSTRUMENT CORPORATION

Write in No. 259 on Reader Service Card at start of Product Preview Section

data preview

MOTORS & ACTUATORS — Drawings and performance curves for over 120 electric motors, linear actuators, rotary actuators, solenoids, and other devices are included in the Electro-Mechanical Catalog, available from **Hoover Electric Co., Dept. S/A Hangar 2, Port Columbus Airport, Columbus 19, O.** Design data relative to the aircraft, missile, ordnance and industrial fields are also included.

Write in No. 292 on Reader Service Card

BERYLLIUM—Reprint 34, a technical discussion of the fabrication of beryllium, has been issued by **The Brush Beryllium Co., Dept. S/A, 4301 Perkins Ave., Cleveland 3, O.** Available forms, properties, and structural fabrication techniques, such as machining, forming and joining, are among the factors covered.

Write in No. 293 on Reader Service Card

WEAPONS SYSTEMS — A 12-page brochure outlining its capabilities in the weapons system, missile, data gathering and other fields is available from **Solar Aircraft Co., Dept. S/A, San Diego 12, Calif.** Support facilities for complete systems development are also described.

Write in No. 294 on Reader Service Card

ROTARY JOINT—Bulletin RAD F-100 containing specifications on Model 15-001 coaxial rotary joint is available from **Radiation Inc., Dept. S/A P. O. Box 37, Melbourne, Fla.** The joint was designed for use in the TLM-18 telemetry tracking antenna system.

Write in No. 295 on Reader Service Card

FACILITIES—Form AV5000 is a new booklet describing the background, experience and facilities relating to secondary power systems management of **Sundstrand Aviation Div., Sundstrand Machine Tool Co., Dept. S/A, Rockford, Ill.** Part of the booklet covers the test equipment used to prove out fluids, synthetic rubbers and metals used in such power system components, and another examines test facilities needed to simulate the high-altitude conditions encountered in supersonic aircraft and missiles.

Write in No. 296 on Reader Service Card

COAXIAL CONNECTORS—Engineering data on its line of coaxial connectors is offered by **General RF Fittings, Inc., Dept. S/A, 702 Beacon St., Boston, Mass.** Announced in the catalog are the new TM series of thread coupled, miniature, coaxial connectors.

Write in No. 297 on Reader Service Card

INSULATION TESTING — A tecinical treatise on insulation testing by dc methods has been prepared by **James G. Biddle Co., Dept. S/A, 1316 Arch St., Philadelphia 7, Pa.** The 45-page Technical Publication 25T1 1958 discusses basic principles, test equipment requirements, and test interpretation methods, among other subjects.

Write in No. 298 on Reader Service Card

RUNNING GEAR—A four-page brochure on running gear for trailer-type equipment has been prepared by **Neway Equipment Co., Dept. S/A, Muskegon, Mich.** The company has designed systems for missile launchers, missile refuelers, airborne trailers, and tank retrievers.

Write in No. 299 on Reader Service Card

SOLDER TERMINALS—Catalog 158, Section 1, containing complete specifications on the Alpine line of solder terminals is offered by **Alpine Electronic Components Inc., Dept. S/A, Waterbury, Conn.** Data on three new terminals designed for molding into plastic headers for use with printed circuits is given.

Write in No. 300 on Reader Service Card

EPOXY TUBING—Information concerning techniques, applications, and specification of epoxy tubing is available from **Redsel Corp., Dept. S/A, Wildwood, N.J.** Redsel epoxy tubing is primarily used for encapsulation of electronic components.

Write in No. 301 on Reader Service Card

PULSE EQUIPMENT — Folder 4MC describes the specialized services available for the production of pulse transformers, chokes, and similar equipment at **Levinthal Electronic Products, Dept. S/A, Stanford Industrial Pk., Palo Alto, Calif.** The bulletin is accompanied by a questionnaire sheet designed to aid response to the details of customer specification problems.

Write in No. 302 on Reader Service Card

TRANSMISSION FILTERS—A report on technical data compiled on the selective transmission of energy through multilayer interference filters is available from **Bausch & Lomb Optical Co., Dept. S/A, 635 St. Paul St., Rochester 2, N.Y.** The report includes data on auxiliary and composite filters and on substrates as well as detailed descriptions of band pass and long-wave length pass filters.

Write in No. 303 on Reader Service Card

PREAMPLIFIERS—A complete line of low noise, high frequency preamplifiers is described in a four-page brochure by **A. R. & T. Electronics, Inc., Dept. S/A, P.O. Box 627, 1101 McAlmont St., Little Rock, Ark.** Specifications of fixed-tuned and center-frequency preamplifiers are given along with several special models.

Write in No. 304 on Reader Service Card

LOOP-VEE ANTENNA—A data sheet describing the Model 15-200-S loop-vee antenna can be obtained from **Radiation Inc., Dept. S/A, P. O. Box 37, Melbourne, Fla.** The antenna is suitable for beam use in the S-band and for telemetering in the 2250-mc band.

Write in No. 305 on Reader Service Card

TRANSISTORS—Data on computer-industrial transistors can be obtained from **General Electric Co., Dept. S/A Electronics Park, Syracuse, N.Y.** PNP germanium types 2N524, 2N525, 2N526, 2N527 are described in data sheet ECG-308. NPN germanium types 3N36 and 3N37 tetrodes are described in data sheets ECG-309 and ECG-314, respectively.

Write in No. 306 on Reader Service Card

TELEMETRY STATIONS — Bulletin 3014 describes the ground telemetry and data processing systems available from **Consolidated Electrodynamics, Systems Div., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.** Applications, operation, and processing procedure are covered.

Write in No. 307 on Reader Service Card

RECTIFIER CONTROLS — Magnetic rectifier controls are described in detail in technical bulletin MRC 658, available from **Fairfield Engineering Corp. Dept. S/A, 934 Hope St., Springdale, Conn.** These controls were designed to drive G.E. silicon-controlled rectifiers (type ZJ-39A) in power control and servo systems.

Write in No. 308 on Reader Service Card

DATA PROCESSING—A 38-page brochure describing application information for the computer language translator is available from **Electronic Engineering Co. of Calif., Dept. S/A, 1601 E. Chestnut, Santa Ana, Calif.** The booklet covers the translation capabilities of the system, the basic translator system, system engineering services, sales or lease terms and maintenance service.

Write in No. 309 on Reader Service Card

more on page 280

Built to handle high pressure hydraulic and pneumatic systems

Snap-Tite *valved* couplings stop flow instantly"

Snap-Tite provides instant shut-off wherever fluid coupling is needed.

Snap-Tite *valved* couplings connect and disconnect quickly and fully—they automatically open line flow when connected; positively seal your line when disconnected—with no "ifs," no chance for human error.

Snap-Tite couplings are available in sizes from ¼" to 6" ID, in steel, brass, aluminum, 303 ss and 316 ss. Sizes from 6" to 10" ID are available on special order. For more information, write for Snap-Tite catalog #58. Snap-Tite representatives are located in all principal cities.

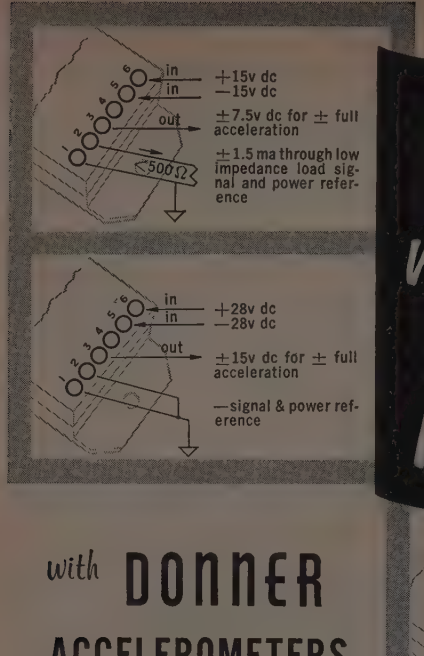
SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

Snap-Tite

ST-59-01

SNAP-TITE, INC. • UNION CITY 14, PA.

Write in No. 260 on Reader Service Card at start of Product Preview Section

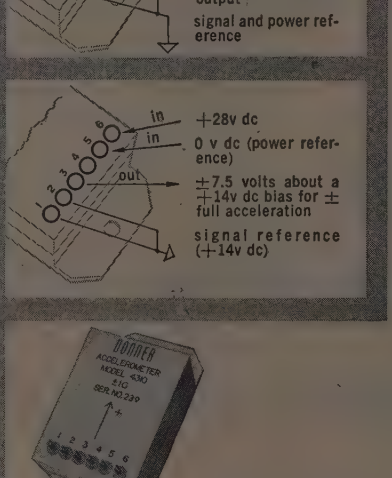

in +15v dc
in −15v dc
out ±7.5v dc for ± full acceleration
±1.5 ma through low impedance load signal and power reference
<500Ω
in +28v dc
in −28v dc
out ±15v dc for ± full acceleration
—signal & power reference

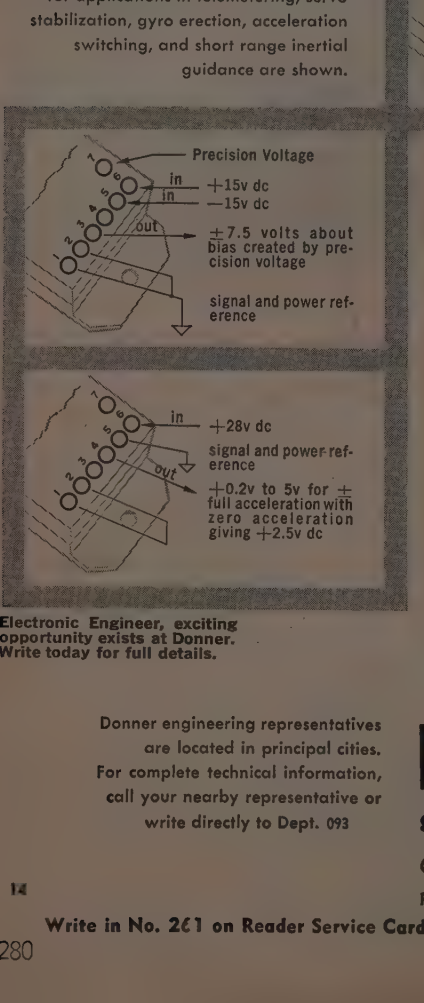
6 ways to solve CONTROL PROBLEMS

with DONNER

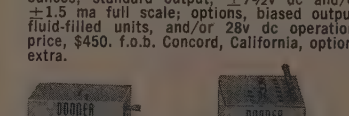
ACCELEROMETERS

Donner 4300 series 0.1% transistorized force balance accelerometers can be connected in a number of ways to solve various control and measurement problems. Typical operational hookups for applications in telemetering, servo stabilization, gyro erection, acceleration switching, and short range inertial guidance are shown.


in +15v dc
in −15v dc
out 0 to 7.5 volts for 0 to plus full scale acceleration, no neg. output
signal and power reference
in +28v dc
in 0 v dc (power reference)
out ±7.5 volts about a +14v dc bias for ± full acceleration
signal reference (+14v dc)


Precision Voltage
in +15v dc
in −15v dc
out ±7.5 volts about bias created by precision voltage
signal and power reference
in +28v dc
signal and power reference
out +0.2v to 5v for ± full acceleration with zero acceleration giving +2.5v dc

Model 4310 high output, high resolution accelerometer. Key specifications: non-linearity plus hysteresis, within 0.05% deviation from best fitted straight line; standard ranges, between ±0.05g full range and ±30g full range; resolution, better than 0.0002% full scale; weight, 3.5 ounces; standard output, ±7½v dc and/or ±1.5 ma full scale; options, biased output, fluid-filled units, and/or 28v dc operation; price, $450. f.o.b. Concord, California, options extra.



Split case version of the Model 4310 for use in limited space applications; electronics on right, sensing unit on left.

Electronic Engineer, exciting opportunity exists at Donner. Write today for full details.

Donner engineering representatives are located in principal cities. For complete technical information, call your nearby representative or write directly to Dept. 093

DONNER

SCIENTIFIC COMPANY

CONCORD, CALIFORNIA

Phone MUlberry 2-6161 • Cable "DONNER"

14

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DATA PREVIEW . . .

ACTUATORS—Definitions of words and phrases pertaining to the field of electro-mechanical actuation and control have been compiled in the Electro-Mechanical Actuator Glossary, prepared by **Hoover Electric Co., S/A, Hangar 2, Port Columbus Airport, Columbus 19, O.** Separate sections are devoted to rotary and linear actuator terminology.

Write in No. 310 on Reader Service Card

SHIELDS—Data sheet 141, describing the multiple function non-shock, sensitive, non-retentive dual Netic magnetic shield can be obtained from **Magnetic Shield Div., Perfection Mica Co., Dept. S/A, 1322 N. Elston Ave., Chicago 22, Ill.** These shields were designed to provide more uniform cooling as well as to direct the magnetic field developed by enclosed solenoid structure when used with traveling-wave tubes.

Write in No. 311 on Reader Service Card

SAGE — A comprehensive 22-page booklet concerning radar data processing for the Sage system is available from **Burroughs Corp., Dept. S/A, Detroit 32, Mich.** Among topics covered are philosophy and integration of the Sage system and the capabilities and future possibilities of the AN/FST-2 system.

Write in No. 312 on Reader Service Card

ELECTRONIC EQUIPMENT — The diversified line of electronic equipment manufactured by **Armstrong Whitworth Aircraft Ltd., Dept. S/A, Baginton, Coventry, England,** is described in a new folder.

Write in No. 313 on Reader Service Card

RF CONNECTORS—Catalog ALRF-1, describing its complete line of coaxial connectors, is offered by **Cannon Electric Co., Dept. S/A, 3208 Humboldt St., Los Angeles 31, Calif.** The 17-page booklet introduces the new ALRF coaxial plugs and the ALA cable connectors.

Write in No. 314 on Reader Service Card

VACUUM TECHNOLOGY — High-altitude aircraft and missile industry design engineers and technical management may be interested in the six-page brochure, "High Vacuum Technology and the Space Age," says **National Research Corp., Dept. S/A, 70 Memorial Dr., Cambridge 42, Mass.** It includes an upper atmosphere vacuum spectrum chart that permits rapid determination of atmospheric density, temperature, pressure, and the mean free path of gas molecules up to an equivalent altitude of 600 mi.

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more on page 282

Write in No. 262 on Reader Service Card→

BRUBAKER ELECTRONICS An R&D leader in the field of ground and airborne IFF components, test and checkout equipments—IFF systems analysis—Air Traffic control systems—radar beaconry—detection equipments.

DATA INSTRUMENTS Pioneers in equipments for fast and accurate analysis of test data, with automatic recording on punched cards, tapes, or printed lists—for aircraft, missile, industrial and scientific uses.

WHITTAKER CONTROLS The largest developer and builder of custom-built high-performance hydraulic, pneumatic, and fuel valves, controls, and regulators for advanced missile, aircraft, and industrial applications.

WHITTAKER GYRO Leaders in electrically driven and spring-wound free gyros, rate and floated rate gyros for missile systems—rate of roll, pitch, and yaw indicators for manned aircraft—bank and turn indicators.

ENGINEERING SERVICES Currently engaged in reduction and analysis of flight test data generated by daily missile firings at Holloman Air Force Base, White Sands Missile Range.

NUCLEAR INSTRUMENTS Designers and builders of high quality, reliable equipments for prelaunch checkout and testing of nuclear special weapons.

When you visit the Telecomputing Corporation booth we'll introduce you to a unique new micro-miniature feed-through capacitor, and a high reliability encapsulated magnetic amplifier. Also featured will be electrically and spring driven gyros, high performance hydraulic, pneumatic and fuel valves, precision analog-to-digital shaft converters, and a recently introduced miniature relay and subminiature capacitor.

TELECOMPUTING CORPORATION 915 N. Citrus Ave., Los Angeles 38, Calif., HO 4-0181

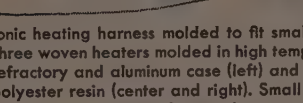
BOOTH 2128

EVERYONE WILL WANT TO VISIT THE TELECOMPUTING BOOTH AT THE IRE SHOW

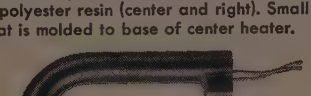
Telecomputing has many exciting job opportunities. Ask at our booth.

CHROMALOX
FLEXIBLE AND MOLDED ELECTRIC HEATERS

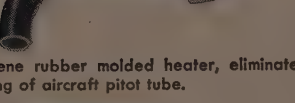
Electronic heating harness molded to fit small object. Three woven heaters molded in high temperature refractory and aluminum case (left) and glass and polyester resin (center and right). Small thermostat is molded to base of center heater.



Neoprene rubber molded heater, eliminates ice clogging of aircraft pitot tube.



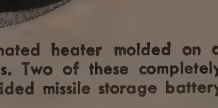
Silicone rubber laminated heater molded on a 2⅛" spherical radius. Two of these completely cover and protect guided missile storage battery reservoir.

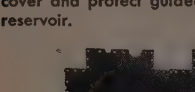


Silicone rubber laminated heater capsulates liquid oxygen valve in guided missiles.

Silicone rubber laminated heater bonded to a metal component for an aeronautical camera.

Neoprene rubber laminated battery heater.





Woven heaters. Temperatures to 800°F. Any size or shape up to 24" wide and to any length. Can be supplied with eyelets, snap fasteners, mounting holes. Moisture and abrasion resistance can be provided by silicone rubber coating.

Chromalox Flexible and Molded Heaters are shaped-to-fit to put exact amounts of heat where it is needed.

FREE—Send today for new Bulletin J-1003 which gives detailed engineering information. Or, call your Chromalox Representative for personal assistance with any heating problem.

4985

CHROMALOX
Electric Heat
INDUSTRIAL • COMMERCIAL • RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7775 THOMAS BLVD., PITTSBURGH 8, PA.

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EXPLOSIVE ORDNANCE — Items such as electric primers, squips and igniters, explosive bolts and Cad cartridges are covered in Data Bulletin CD-1-57, put out by McCormick Selph Associates, Dept. S/A, Hollister Airport, Hollister, Calif. Applications of the explosive ordnance line to the aircraft rocket and missile fields are presented.

Write in No. 316 on Reader Service Card

O-RING SEALS—"Parker O-ring Handbook 5700" covers the subject of design and application of synthetic rubber O-ring seals. The 160-page booklet includes numerous illustrations, tables, charts, and other valuable data, is available from Rubber Products Div., Parker Appliance Co., Dept. S/A, 17325 Euclid Ave., Cleveland 12, Ohio.

Write in No. 317 on Reader Service Card

BOLTS & NUTS—A new, eight-page brochure discussing indetail advantages of the Blind Bolt and the Blind Nut, structural and repair applications, design characteristics, tools and guns, installation techniques and hydraulic power units for driving bolts, is published by Hi-Shear Rivet Tool Co., Dept. S/A, 2600 W. 24th St., Torrance, Calif.

Write in No. 318 on Reader Service Card

SOLENOID VALVE—A 114-page catalog, with eight indexes, construction details, and flow diagrams on solenoid valves is available from Automatic Switch Co., Dept. S/A, Florham Park, N. J. About 1400 items are listed.

Write in No. 319 on Reader Service Card

BALL BEARINGS—A 38-page, two-color precision instrument ball bearing catalogue is available from General Motors Corp., New Departure Div., Dept. S/A, Bristol, Conn. The catalogue lists and illustrates the company's facilities and a full range of bearings of instrument classification, as well as lubrication, operation, speed, packaging, and bearing equivalents tables.

Write in No. 320 on Reader Service Card

STAINLESS STEEL—An illustrated 32-page catalog offering the description, chemical composition, strength factors, physical properties and typical applications for a broad range of stainless types including the 200, 300 and 400 series of stainless steels is available from Sharon Steel Corp., Dept. S/A, Sharon, Pa.

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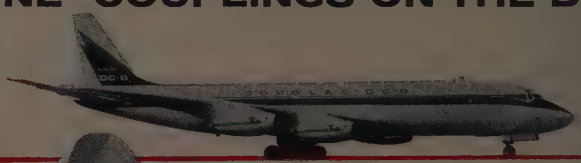
more on page 286

ON MARK COUPLINGS

NEW ON MARK FLEXIBLE LINE COUPLINGS ON THE DC-8



Standard equipment on the Douglas DC-8 fuel lines is ON MARK's new Flexible Fluid Line Couplings. Vastly superior to old style "AN" tube unions, this new coupling has been tested far beyond the requirements of specification MIL-C-25014 with simultaneous flexure, axial motion and pressure cycling at −65°F. WITH NO DEVIATION. Simpler in design, easy to assemble (NO SPECIAL TOOLS NEEDED), and lighter, the ON MARK coupling seals on deformed, marred and scratched tubing at all temperatures. Tests prove these couplings to be equally effective for special requirements such as hot air, gases, exotic fuels, and vacuum.

***In production* in standard tubing sizes.**

For full information please contact

ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California
Telephone CLinton 4-2278

Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y.; Divisions of The Garrett Corporation;

Write in No. 264 on Reader Service Card at start of Product Preview Section

A Logical Deduction

Because The design of an NJE SOLID STATE transistorized power supply permits *no compromise with quality;*

Because every transformer and choke is a *MIL-T-27-A* style unit; every resistor is *wire-wound*; every capacitor is the *finest* of its type;

Because *every* component is significantly derated at the *worst combination* of line, load, and ambient conditions, including repeated short circuits and critical partial overloads;

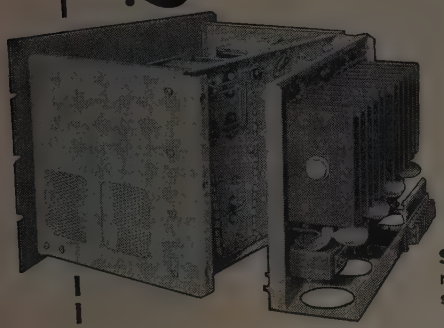
Because NJE "regulation" is the *total* of the *worst simultaneous combination* of line and load effects, static and dynamic;

Because NJE circuitry provides *stability,* against both time and temperature, *better than the rated regulation;*

Because we build all 14 standard models from three mass-produced "building blocks", *very competitively,* despite higher quality,

It follows that your best buy in a transistorized power supply is NJE SOLID STATE.

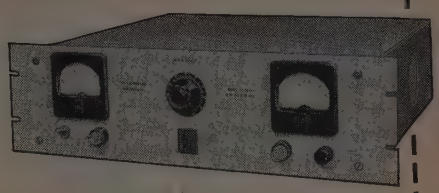
QED...choose NJE



SS-32-20,
rear view,
showing swing-out panel.

New Lower Prices,
Tighter Specifications!

Write for complete catalog



SS-10-10,
5¼" panel,
17½" deep.

MODEL	VOLTS	AMPERES
SS-7-15	0-7	0-15
SS-10-10	0-10	0-10
SS-10-50	0-10	0-50
SS-18-2	0-18	0-2
SS-32-3	0-32	0-3
SS-32-10	0-32	0-10
SS-32-20	0-32	0-20

MODEL	VOLTS	AMPERES
SS-36-1	0-36	0-1
SS-1603	0-160	0-1.5
SS-1605	0-160	0-3.0
SS-3600	10-36	0-50
SS-1503	100-150	0-1.5
SS-3003	200-300	0-1.5
SS-1505	100-150	0-3.0

NJE CORPORATION
345 Carnegie Avenue, Kenilworth, New Jersey
CH 1-1500 TWX - ROSELLE, N.J. 51 FAX - FFP

WE CATALOG IN eem electronic engineers master

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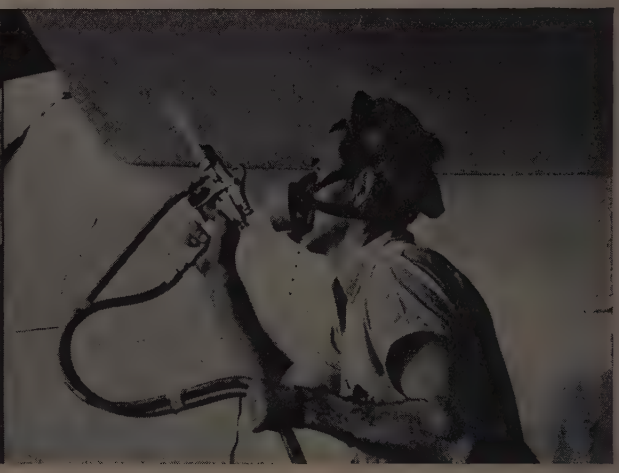
BUILD IN STRENGTH, DURABILITY with 3M Adhesives, Coatings and Sealers

DRY/LIQUID ADHESIVE. 3M Composite Film Adhesive AF-201 turns liquid only under bonding heat. As a result, you avoid the messiness and handling difficulties of previous sandwich bonding adhesives. Yet you gain both deep filleting of honeycomb and high peel strength along with faster, more economical sandwich section fabrication.



EROSION RESISTANT. 3M Coating EC-1303 has served over eight years on high-speed military aircraft without reported failure due to rain or dust erosion. This erosion and corrosion resistant coating has withstood service at ambient temperatures from −65°F. to +100°F., skin temperatures up to +180°F. without failure.

STAYS FLEXIBLE. Vibration and flexing will not destroy integral fuel tank seals of 3M Sealer EC-801. This two-part, chemically-curing sealer is highly resistant to constant exposure to aircraft fuel, remains flexible, adheres firmly to metal despite temperatures from −65°F. to +180°F.

RESISTS HIGH HEAT. Even operational temperatures up to 300°F. don't destroy integral fuel tank seals and pressurized cabin seals with 3M Sealer EC-1293. This filleting-type, two-part compound cures chemically to a tough, rubbery, white solid, upon addition of the accelerator. Curing requires no heat, pressure or air.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU—Contact your 3M Field Engineer. Or, for more information and free literature about 3M adhesives, coatings and sealers for the aircraft and missiles industries, write on your company letterhead to: A.C.&S. Division, 3M, Dept. YB-39, 900 Bush Avenue, St. Paul 6, Minnesota.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

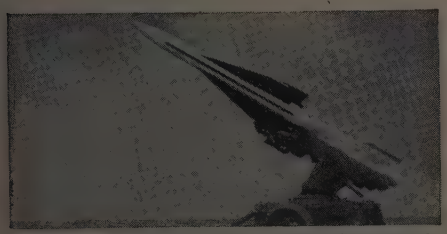
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

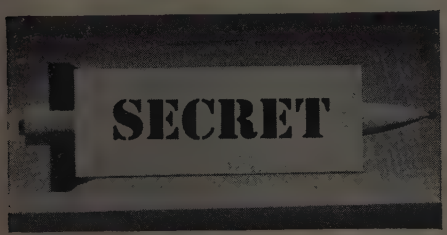
Write in No. 266 on Reader Service Card at start of Product Preview Section

Raytheon Missile Projects

SPARROW III—the Navy's tenacious, lightning-fast, air-to-air missile—is intended for extensive use by Navy fighter aircraft in fleet air defense. Sparrow III is a Raytheon prime contract.

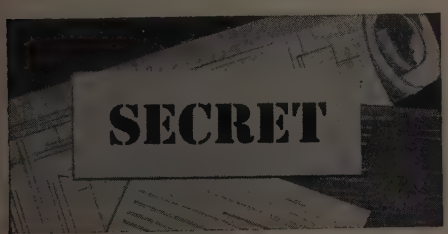


HAWK—the Army's defense against low-altitude attackers—carries out its destruction in the blind zone of conventional radars. Hawk development and production is under Raytheon prime contract.



TARTAR—A substantial contract for vital electronic controls for this Navy destroyer-launched missile is held by Raytheon. This equipment—a tracking radar and associated units—enables it to "lock on", cling to target's path, despite evasive tactics.

ADVANCED PROJECTS in aeronautical structures as well as missile guidance and control are now underway in Raytheon laboratories. New facilities are continually being added for this work.



PRELIMINARY NEW DESIGNS of tomorrow's missiles will result from the advanced work being done by today's missile engineers. Raytheon plays an important role in this area.

Raytheon diversification offers

JOB STABILITY FOR CREATIVE MISSILEMEN

Here is an opportunity to free yourself of worry about a job that's here today, gone tomorrow.

Diversified assignments—only possible in a company with Raytheon's wide range of missile activities—means security not found in one- or two-project companies. You apply your creative energies to the many projects you work on, and they in turn are your "insurance" against falling into a rut.

Individual recognition comes quickly from Raytheon's young, engineer-management—men who are keenly aware of the engineer's needs and contributions to missile progress.

Dynamic Raytheon growth—the fruit of this management's progressive policies—is best illustrated by the fact that Raytheon is already the only electronics company with two prime missile contracts—Navy Sparrow III and Army Hawk.

The next step is up to you. Why not get frank answers and helpful information on the type of job suited to your background and talents, its location, salary and other important details. Write, wire or telephone collect: The number is CRestview 4-7100 in Bedford, Massachusetts. Please ask for W. F. O'Melia.

RAYTHEON OPPORTUNITIES NOW OPEN IN:

WEAPONS SYSTEM ANALYSIS • CONTROL SYSTEMS • PACKAGING • MICROWAVE • RADAR • SPECIFICATIONS • MISSILE AERODYNAMICS • WIND TUNNEL TESTING • AERODYNAMIC HEATING • ROCKET ENGINEERING • VIBRATION MEASUREMENT and DATA REDUCTION

RAYTHEON MANUFACTURING COMPANY
Missile Systems Division, Bedford, Mass.

RAYTHEON *MISSILE SYSTEMS DIVISION*

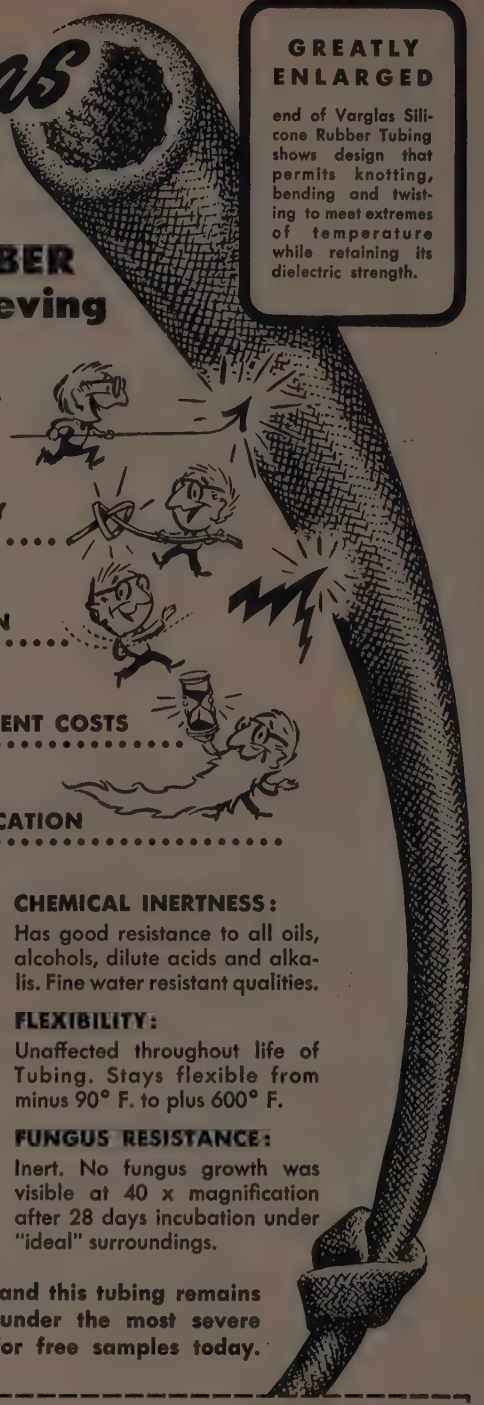
Excellence in Electronics

Check Employment Inquiry Form on Page 175

5 Ways Better...

Varglas

SILICONE RUBBER
Tubing and Sleeving



GREATLY ENLARGED

end of Varglas Silicone Rubber Tubing shows design that permits knotting, bending and twisting to meet extremes of temperature while retaining its dielectric strength.

1. WON'T CRACK, PEEL OR CRAZE
2. GREATER FLEXIBILITY
3. HIGH DIELECTRIC RETENTION
4. LONG LIFE CUTS REPLACEMENT COSTS
5. VIVID COLORS FOR READY IDENTIFICATION

THERMAL PROPERTIES:
Heat aging: 1000 hrs. at 250° C without appreciable change in physical or dielectric properties.

FLAMMABILITY:
Self-extinguishing, when tested in accordance with ASTM and NEMA procedures. (NEMA Acceptance Test).

ABRASION RESISTANCE:
Durable and extra tough. Withstands unusual rough handling at all times.

CHEMICAL INERTNESS:
Has good resistance to all oils, alcohols, dilute acids and alkalis. Fine water resistant qualities.

FLEXIBILITY:
Unaffected throughout life of Tubing. Stays flexible from minus 90° F. to plus 600° F.

FUNGUS RESISTANCE:
Inert. No fungus growth was visible at 40 x magnification after 28 days incubation under "ideal" surroundings.

Twist, bend, wrap or knot it and this tubing remains pliable and efficient, even under the most severe operating conditions. Send for free samples today.

Varflex SALES CO., INC. Insulation SPECIALISTS Rome, N. Y.

VARFLEX SALES CO., INC.
316 N. Jay St., Rome, N.Y.

Please send me sample with Bulletin and Prices.

Name_____

Title_____

Company_____

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DATA PREVIEW

CONNECTOR TESTS—Details on the laboratory testing of miniature electrical connectors have been issued by **The Deutsch Co., Dept. S/A, 7000 Avalon Blvd., Los Angeles 3, Calif.** A 29-page test report describes a complete series of tests for electrical, environmental and physical characteristics.

Write in No. 322 on Reader Service Card

TRANSISTORS—Composite transistors and diodes are discussed in Bulletin 505 by **Advanced Research Assoc., Inc., Dept. S/A, P.O. Box 68, Kensington, Md.** A series of data sheets on these units is also available.

Write in No. 323 on Reader Service Card

RECORDINGS—**Electronics Assoc., Inc., Dept. S/A, Long Branch, New Jersey,** is distributing a folder describing and illustrating its Model 1100E Variplotter. It also includes technical specs.

Write in No. 324 on Reader Service Card

COMPUTERS—Bulletin CC-821 describes the analog computing equipment which has been installed for company use in three cities and is available from **Electronic Assoc. Inc., Technical Literature Group, Dept. S/A, Long Branch, N. J.**

Write in No. 325 on Reader Service Card

FLASHERS—A technical bulletin entitled "Static Flashers" has been released by **Electronic Specialty Co., Dept. S/A, 5121 San Fernando Road, Los Angeles 39, Calif.**

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CLIPS—Catalog 200 itemizes a complete line of electrical clips and insulators made by **Mueller Electric Co., Dept. S/A, 1583 E. 31st St., Cleveland 14, O.** Among the units covered are miniature and standard-size alligator clips, and heavy-duty test and battery clips.

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TELEVISION—Bulletin GEA-6833 (6 pages) describes in text tables and pictures the advantages of closed-circuit TV for military use. It is being distributed by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.**

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SEALED RELAYS—Bulletin GEA-6628 (24 pages) offers information on hermetically sealed relays for military and general purpose industrial applications. It is being offered by **General Electric Co., Dept. S/A, Schenectady 5, N. Y.**

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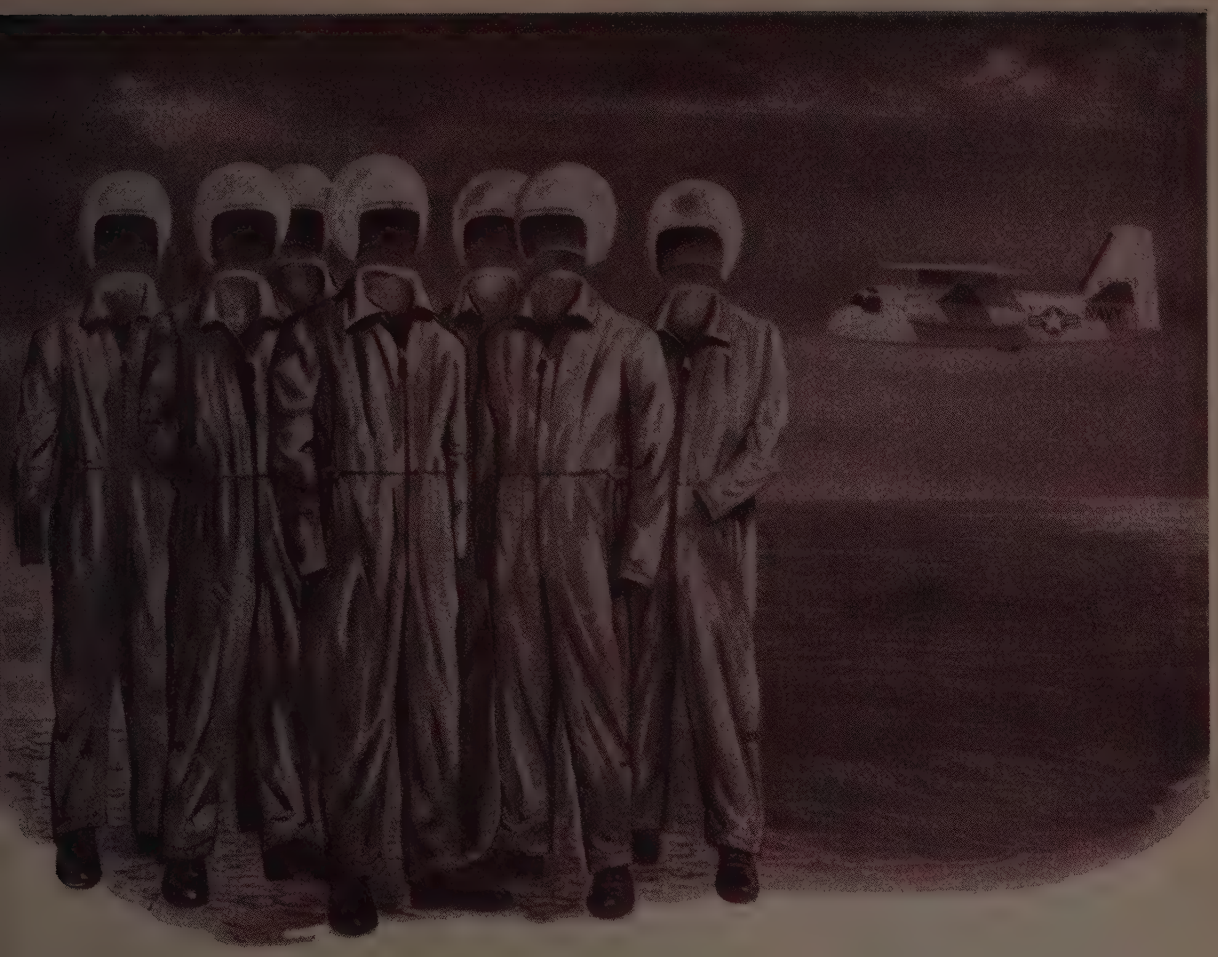
more on page 288



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Aeroquip WEBLOCK Straps

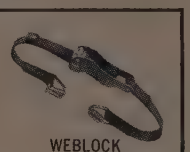
SIMPLIFY HANDLING OF ROCKET THRUST CHAMBERS AT ROCKETDYNE

Thrust chambers are palletized for handling.

Use of Aeroquip WEBLOCK Strap Assemblies can solve many materials handling problems. At Rocketdyne, division of North American Aviation, Inc., a simple nylon strap harness was developed to secure top-heavy rocket thrust chambers on pallets. Harness attachment is quick and easy. Tension is automatically locked with a pull of the WEBLOCK Strap, released with finger touch.

Outline your aircraft or missile tie-down requirements and let General Logistics provide simple, low-cost answers. Mail coupon below for details.

Ratchet Tie-Down Buckles



WEBLOCK Strap Assemblies

General LOGISTICS
A DIVISION OF Aeroquip CORPORATION

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☐ Ratchet Buckle ☐ WEBLOCK Straps

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DATA PREVIEW

LOADS & HARDNESSES—An illustrated brochure covering its facilities and production of leads and harnesses, built to meet stringent military requirements, is available from **General Laboratory Associates, Inc., Dept. S/A, Norwich, Conn.**

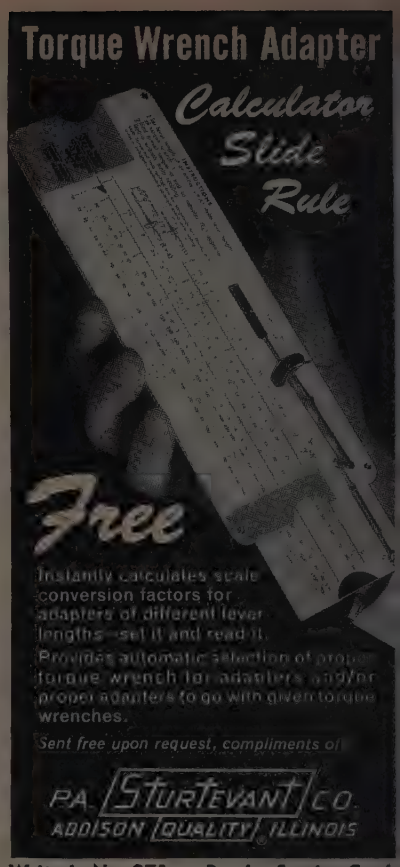
Write in No. 330 on Reader Service Card

MERCURY SWITCH—A new nylon-enclosed mercury switch, fabricated of materials which are highly resistant to the effects of water, oil, alkalis and acids, is described in a data sheet from **Micro Switch, Dept. S/A, Freeport, Ill.** Photographs, price information, mounting clip data and electrical ratings are included.

Write in No. 331 on Reader Service Card

TURBINE FLOWMETERS—Bulletin No. 1314 describes the operation accuracy, serviceability, and specifications of the Cox Type 20 turbine flowmeter for measuring the flow of jet fuel, gasoline, water, chemicals, and other liquids over a wide range of temperatures and pressures. It is available from **George L. Nankervis Co., Commercial Research Div., Dept. S/A, 15300 Fullerton Ave., Detroit 27, Mich.**

Write in No. 332 on Reader Service Card


Torque Wrench Adapter
Calculator
Slide
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Free
Instantly calculates scale conversion factors for adapters of different lever lengths—set it and read it.
Provides automatic selection of proper torque wrench for adapters and/or proper adapters to go with given torque wrenches.
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LIGHT IN WEIGHT!

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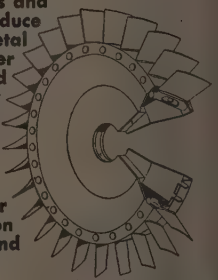
LOW COST!

WE ELIMINATE COSTLY MACHINING!

Stalker's modern facilities and advanced techniques produce precision-formed sheet metal rotors — 50% to 75% lighter than more costly machined counterparts. Lighter weight rotors mean lighter weight engines — and greatly increased pay loads.



To customers with products requiring precision fabrication and high temperature brazing of stainless steel and super alloys, Stalker also offers complete testing and inspection facilities. U.S. Air Force certification for both brazing and heat treat.

Whatever your problem may be, our engineering, development and production facilities are at your disposal. Write, wire or phone for information.

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Write in No. 256 on Reader Service Card →

VISIT US AT THE I.R.E. SHOW
BOOTH NUMBER 3413

New motor ideas from Mechatrol

? 400 cycle motor ideas are coming from Mechatrol, on of Servomechanisms, Inc. And these ideas are being work by America's leading missile manufacturers. In fewer than thirty different missiles contain motors or ackaged rotating components bearing the Mechatrol ate. They were selected on the basis of advances in high performance and proven reliability.

SMI's Mechatrol Division specializes in motors from BuORD size 20 down to size 5. These include Servo and Synchronous types with or without integral gearheads, Velocity and Acceleration Damped Servo Motors, Damping and Integrating Motor Tachometers and other miniature electromechanical packages. We specialize, too, in delivering these components on schedule, to meet critical production and test programs.

grade system performance and reliability, we mend that you investigate the advantages nt in Mechatrol motors and other rotating nents. We would be pleased to send you our otor catalog which provides complete techni- ta on these new rotating components. Please equests on your company letterhead.

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MECHATROL DIVISION

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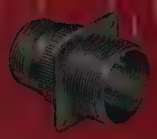
wherever high temperatures are encountered you can get full protection by using Cannon Steel Shell High Temperature Connectors to protect electrical circuits.

500° F

1000° F

2000° F

HEAT RESISTANT...



MS-K receptacle with crimp-type contacts

FW-23 plug, either crimp or solder-pot contacts

FWR-31SL wall mount receptacle, socket insert

FWR-22 plug, pin insert assembly

Cannon Electric supplies both MS-K and FW fireproof types of electrical connectors for the protection of vital circuits in flame barrier applications.

The fireproof test of Military Specification MIL-C-5015 assures that a connector will carry a specified current for 5 minutes and prevent the passage of flame for twenty minutes while being subjected to a flame of 2000°F. Cannon MS-K Connectors meet this specification.

In addition to firewall plugs Cannon Electric has developed connectors that operate continuously up to 1000° F. Developments are under way that will increase the temperature range. We would like to suggest that you will find it well worth your while to consult our engineering personnel for full information on the newest high temperature connectors available.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

Please refer to Dept. **115**

More than 27,000 Cannon Connectors assure you the opportunity of selecting exactly the right connector for any particular application you have in mind. Please write for new 44-page, 2-color Cannon Plug Guide, Bulletin CPG-3.

CANNON PLUGS

WHERE RELIABILITY IS THE 5th DIMENSION

AWARENESS OF PROBLEM — INTEGRITY OF INTENT — DESIGN EFFORT — MANUFACTURING CONTROL

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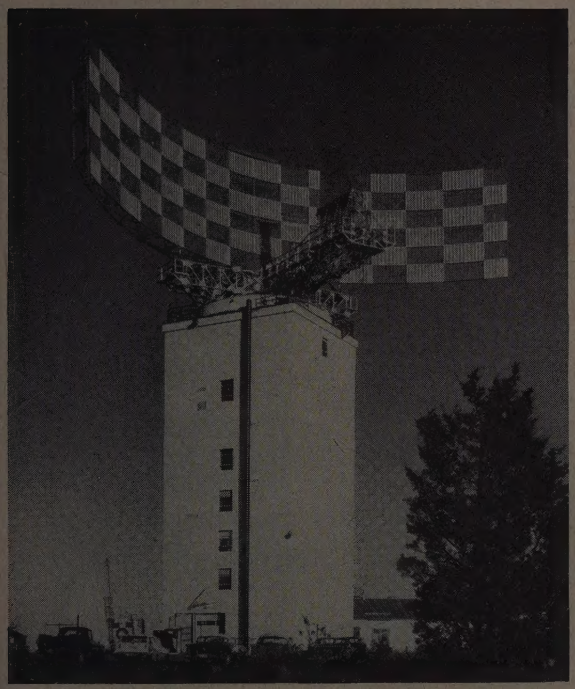
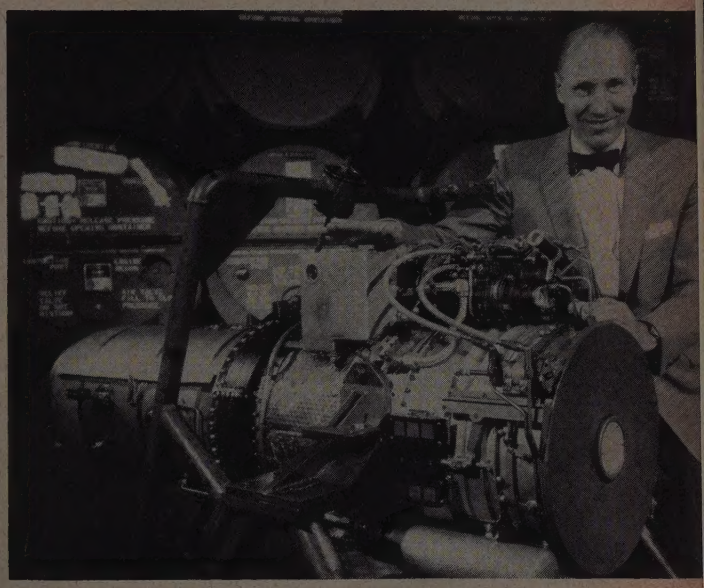
industry briefs

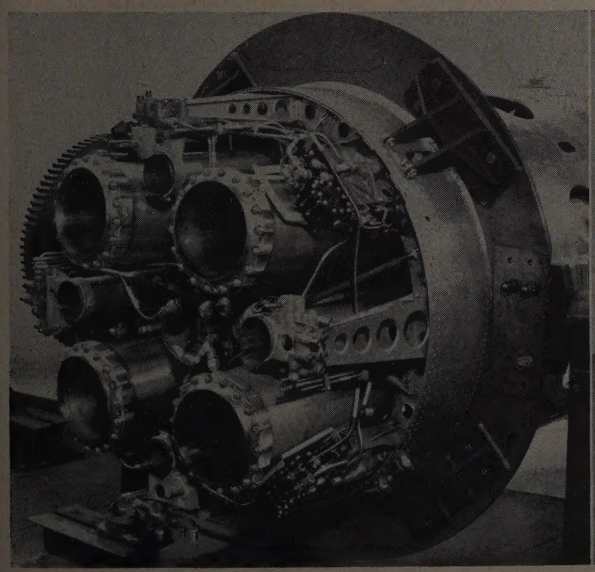


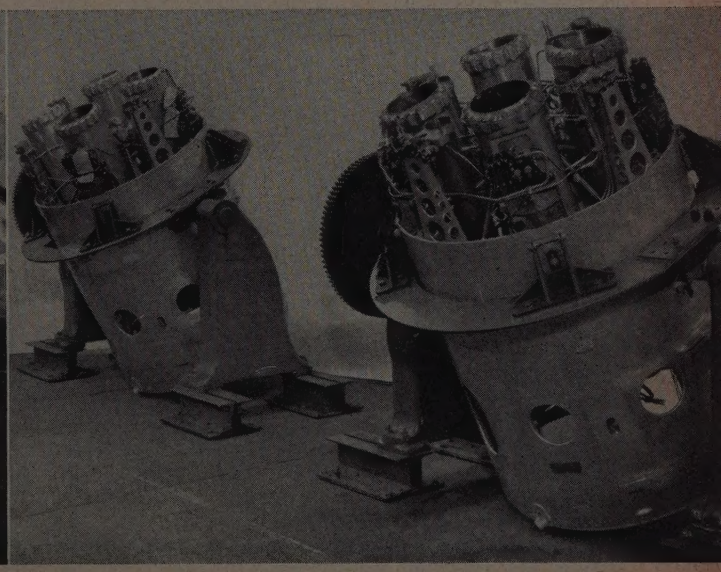
EXPERIMENTAL high power radar designed by Lincoln Lab has 120x30-ft reflector, is accurate to less than 1/10 deg rotating at up to five rpm in 60-mph winds.



FIRST VIEW of GE's lightweight J85, now in flight test in McDonnell's GAM-72 decoy missile. The turbojet has a thrust in the 2000-lb class, says GE, which gives it one of the highest thrust-weight ratios among all gas turbines now in production. The engine is also slated for use on North American's 10-passenger T-39 Sabreliner transport and on Northrop supersonic T-38 trainer.

FOUR combustion chambers are used in Armstrong Siddeley Gamma rocket, powerplant of Britain's Black Knight re-entry test vehicle. The four chambers are arranged about a central support, rotate on trunnions about axes radiating from the support. Weighing around 700 lb, the Gamma has a sea level thrust of 16,400 lb.





←Write in No. 274 on Reader Service Card

Designers need thermal data

FOR ABOUT five years I've been in aircraft and missile thermal design, development and production. To me, this has been rather fortunate, because this specialization has given me a comparatively broad insight into the thermal problems of supersonic and hypersonic flight.

One of the most pressing problems plaguing thermal designers now is the lack of materials—either for the basic structure or for insulation (including high and low emissivity coatings)—for high temperature uses. Coupled with this is the lack of thermal physical property data for detailed heat transfer analyses even on some of the so-called developed materials.

Formerly, thermal analyses were limited and generally not needed, since the structural heating effects of aerodynamic heating could be ignored. Now, however, with increased flight speeds, steady and transient state thermal analyses have taken a leading role in the design of aircraft and missiles. In many cases, a good thermal analysis can be the big factor in meeting performance requirements.

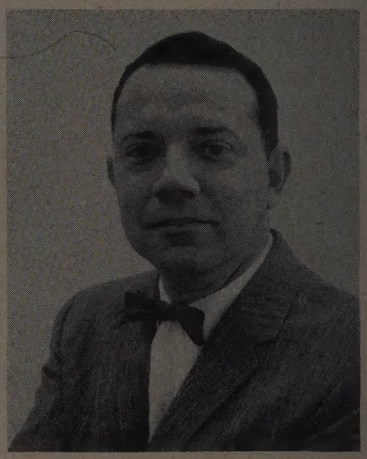
In line with this added stress on thermal studies has arisen the need for an accurate, up-to-date compilation of thermal properties to support the analyses.

Materials groups generally get this responsibility. But new materials are being developed at such a pace that these materials groups just can't keep up with the job of compiling and correlating these data. Frankly, they themselves have a new horizon of other problems such as attachment methods, producibility, bonds, fuel tank sealants, mechanical properties, and the like, which they're better suited to handle. To make a materials engineer responsible for evaluating thermal property data is an injustice, both to him and to the heat transfer specialist.

One big weakness is that new materials are developed and advertised when thermal data haven't yet been determined. It isn't at all unusual for a designer to read an article saying a manufacturer has developed an insulating material that can operate in, say, the 1000-2000-deg F range. However, if he writes to the manufacturer and asks—as a function of the given temperature range—the three basic properties (thermal conductivity, specific heat, and density) defining insulating capability, rarely can he get them at any temperature other than room temperature!

Those of us who are even more naive will ask for emissivity, solar absorptivity, and heat of fusion—with even less success.

Maybe we shouldn't gripe at the manufacturer. After all, the equipment to get the data is costly, and sometimes isn't available. Nevertheless, this lack of data may mean that each designer must get such data by test. I say "each", because even though the data has been obtained by one company, it isn't necessarily available to all, since it may be termed proprietary.



JOSE I. GONZALEZ, Design Engineer, The Martin Co., Orlando Div., Orlando, Fla.

Finally, take the case of a comparatively common material. Here the situation is reversed. Generally, there is an abundance of thermal physical property data. Now the problem is one of sifting through data that is contradictory and shows large variations even for materials of identical composition.

I am aware that Purdue University is trying to fill this void with their Thermal Properties Research Center. This certainly is a step in the right direction, and industrial support should be encouraged.

Other efforts to centralize the compilation of these types of data are needed. Duplication of effort in industry—although necessary to some extent—can be reduced by panels similar to those of the National Academy of Sciences.—End

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Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

THIOKOL AT ELKTON MARYLAND

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CONVAIR'S B-58 HUSTLER and CONVAIR'S ATLAS ICBM

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